Watts Branch Watershed Study and Management Plan Final Report

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City of Rockville

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EXECUTIVE SUMMARY

This report provides a summary of the findings and recommendations from a three phase Watts Branch Watershed Study and Management Plan project conducted by the Center for Watershed Protection (Center), Environmental Systems Analysis (ESA), and Macris Hendricks, & Glascock (MHG) for the City of Rockville, MD Department of Public Works. The primary goal of the Watts Branch project was to develop a watershed protection plan that establishes a program aimed at mitigating many of the impacts and stresses that exist on the ecosystem. Specific watershed protection goals of the plan, as identified by the City and its residents, include:

- Minimize/control channel enlargement (i.e., channel erosion)
- Reduce pollutant loadings from nonpoint source runoff
- Develop stewardship among residents by educating and changing behaviors
- Protect existing utilities in and near streams from erosion damage
- Provide stormwater management control over a significant proportion of the watershed (or subwatershed)
- Protect existing forest areas
- Protect existing wetlands
- Protect existing active recreational areas

The watershed study and management plan for Watts Branch employed principles of a rapid watershed planning approach, with an emphasis on "stakeholder" involvement. The City needed a workable plan for implementation of specific management measures that balanced the inevitable tradeoffs between environmental protection and an urban population. To develop the right balance, the City staff formed a partnership with interested residents, civic and homeowners' association representatives, and environmentally concerned citizens to review the methodology, findings and recommendations of the study. The Watts Branch Partnership helped tailor proposed projects to meet neighborhood needs as much as possible and still achieve the watershed objectives. The Partnership members also acted as liaisons to their communities to inform people of the watershed study and convey comments back to the staff.

The first phase of the project was a watershed assessment and preliminary plan development stage, where the existing conditions within the watershed were documented and potential management measures are put forth. Specific tasks included:

- Conducting a stream geomorphic assessment to assess the dynamic stream evolutionary process associated with altered urban hydrology
- conducting a biological, physical and chemical stream survey to identify overall stream health and identify specific problem areas
- Identifying potential stream rehabilitation and stormwater retrofit sites within the watershed
- Facilitating a watershed planning charette to engage watershed stakeholders in the planning process, and
- Preparing preliminary recommendations for employing management measures.

A Phase I Watts Branch Watershed Study Report was prepared and submitted to the City in March, 2000, describing in detail the findings of the above tasks.

In the second phase, the project team prepared conceptual designs, cost estimates and analyses of estimated benefits for specific watershed management measures such as stormwater management retrofits, stream rehabilitation, wetland enhancement, and forest conservation.

In the third and final phase, the project team developed management recommendations for public outreach and education, bench mark and long term monitoring, and prioritization of implementation.

E.1 Background

Watts Branch is a tributary to the Potomac River located in suburban Maryland approximately 15 miles northwest of Washington, DC. The Watts Branch watershed area within the City of Rockville limits is approximately 6.5 square miles and has over 18 miles of streams. This area includes all of the headwater streams of the watershed. In general, the mainstem of Watts Branch flows from north to south.

The land use within the watershed is comprised of a mixture of residential, commercial, and institutional, with single family residential being the most common land use. The current impervious cover for the Watts Branch watershed within the City of Rockville is approximately 28 percent. The impervious cover is an important and useful indicator that can be used to define what current watershed conditions are as well as to formulate realistic goals for what the prospects are for improvement in response to mitigation and rehabilitation efforts.

Existing water quality and macroinvertebrate data indicate that over time, there has been a decline in water quality and the diversity in the benthic macroinvertebrate communities. An obvious factor has been the nearly continuous conversion of this watershed from agricultural to urban land use over the last 50 years. With the current and planned development of the last two significant parcels of contiguous land (King Farm and Fallsgrove), the Watts Branch watershed will reach a condition known in the land planning world as essentially full “buildout.”

The Watts Branch watershed is somewhat unique in that it is a rare example of a watershed that has been scientifically studied over time. The renowned fluvial geomorphologist, Dr. Luna Leopold, had the foresight to study in detail the Watts Branch watershed over a 20-year period (1953 to 1972) in an attempt to establish a database from which to track and analyze changes in a small headwater channel. Leopold observed a trend of initial aggradation followed by degradation (i.e., channel enlargement) in Watts Branch. The enlargement has continued through the 1990s and can be directly related to the degree and rate of urbanization. The adverse impacts associated with the channel enlargement are a major reason for this watershed planning effort.

Watts Branch was analyzed during the first phase of the project using a suite of rapid watershed diagnostic techniques including: the impervious cover model, the Rapid Geomorphic Assessment (RGA), the Rapid Stream Assessment Technique (RSAT), and hydrologic modeling (TR-20). The impervious cover model was used to assist in establishing realistic watershed management objectives, the RGA was performed to evaluate channel stability, and the RSAT was implemented to determine the physical attributes of all perennial reaches of Watts Branch. Hydrologic modeling was undertaken to provide additional runoff information to use in assessing the geomorphologic status of the stream, to assess the effect of existing and proposed stormwater facilities, to use for conceptual designs for stormwater facilities and to update the study previously prepared for the City. In addition, stormwater retrofit and stream rehabilitation inventories were conducted, in which potential retrofit sites were identified and conceptual-level sketches were developed.

The Phase I information was in turn used to develop and refine conceptual-level designs of stormwater retrofit and stream rehabilitation sites. A series of "30%" design drawings showing plan and profile details were developed for the priority sites. In addition, wetland improvement and reforestation recommendations were developed based on the reconnaissance level information collected during the rapid field assessments.

The project approach also placed an emphasis on getting input and involvement from the public early in the planning process through workshops and Partnership meetings. The project scope was developed to ensure that public involvement and participation remains a component of the watershed plan well after the immediate project.

E.2 Analysis

An important task of the Watts Branch project was to define the stream channel geomorphic characteristics. The assessment of the physical characteristics of the stream channel serves as an important foundation of the stream rehabilitation strategies and provides a reference on where the stream is in its evolutionary process. In addition, the documentation of current channel conditions can be used as an indicator of future trends in stream channel characteristics.

Streams characteristically enlarge as result of urbanization. Past investigations have found that channel enlargement is a function of basin imperviousness as well as the corresponding age of that impervious cover. The simplest way to quantify these changes is to define an "enlargement ratio," which represents the ratio of a stream's current cross-sectional area to its pre-development cross-sectional area (or, in some cases, a cross-section from an adjacent undeveloped stream of equivalent watershed area.)

To illustrate the concept of channel enlargement, Figure E.1 is presented comparing a channel cross-section as it evolves over time. The change in channel morphology is illustrated by superimposing the cross-sectional area of a channel at three distinct points in time: historic, current, and ultimate. Historic cross-section data are obtained from past surveys (often obtained from transportation agencies or public works departments that conducted surveys at the time of road construction or improvement projects), current cross-sectional data are obtained from field surveys conducted at the time of the study, and ultimate cross-sectional data are generated using predictive (i.e., empirical) equations based, in part, on the historic and current cross-sections.

The channel enlargement analysis documented some important findings about where Watts Branch is along the evolutionary time line. In general, it appears that the Watts Branch channels are only about 30 to 40 percent of the way along the evolutionary process. Therefore, another 40 to 50 years of channel reaction and adjustment to development influences is expected before a state of quasi-equilibrium is reached. In addition, the channel cross-sectional area is expected to increase two to four times its current size, depending on the location.

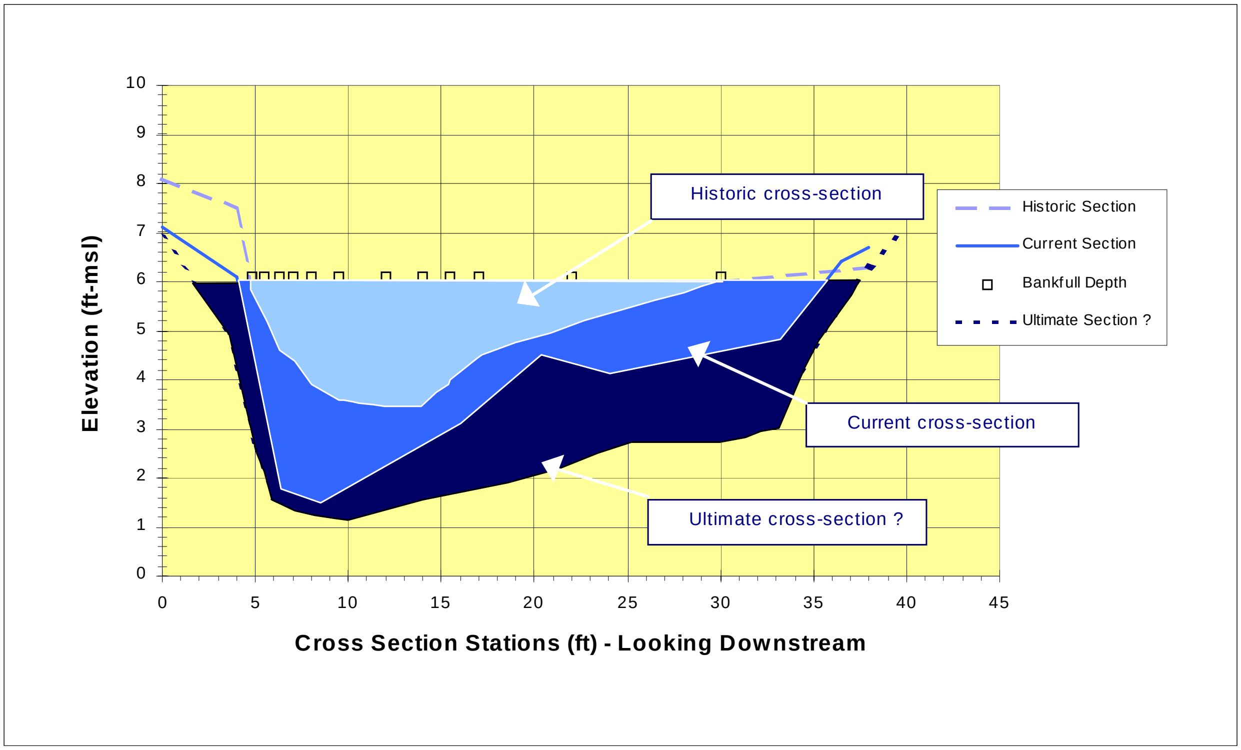


Figure E.1 Watts Branch cross-section comparison (Note: cross-sections have been overlaid for illustrative purposes only–actual sections do not share same datum.)

These findings were important to the overall strategy that was taken from a stream rehabilitation and stormwater retrofit standpoint. Specifically, since the study points indicate that the stream channel still has a long way to go before reaching a state of relative equilibrium, the in-stream rehabilitation techniques implemented for the most part focused on practices able to withstand adjustments in channel downcutting, widening, and plan form. It should be noted that there are certain reaches that required more substantial channel protection measures (e.g., imbricated riprap) where property or utility crossing impacts was a primary consideration. In addition, because there is a large increase in channel cross-sectional area predicted, an important focus of the stormwater retrofitting was on providing channel protection storage (i.e., 24-hour extended detention of the 1-year return frequency storm) to help mitigate the erosive forces associated with the stormwater runoff.

The physical stream assessment that was conducted generally supports the findings of the geomorphic assessment, namely that the majority of stream reaches within the watershed show signs of being impacted by urbanization. While the majority of the stream reaches ranked either good or fair overall, the assessment enabled specific metrics (e.g., riparian habitat conditions) to be analyzed and targeted for future management recommendations.

A significant reason for the adverse impacts being seen in Watts Branch is that the existing stormwater treatment practices are inadequate or were built to provide only peak discharge controls for larger storm events (e.g., the 2- or 10-year storms), and have little capability to control channel erosion or remove stormwater pollutants. Improving water quality through reducing the pollutant load delivered to the stream is an important goal of the project for several reasons. First, there is a strong desire by the City and Montgomery County to protect and enhance the aquatic and terrestrial ecosystems along the stream corridor, as well as improve the appearance for park users. Second, the confluence of the Potomac River and Watts Branch is just upstream of a major Washington Suburban Sanitary Commission drinking water intake for suburban Maryland; consequently, the water quality of Watts Branch can have a significant impact on the level of treatment required at the drinking water plant. Lastly, Watts Branch is a tributary to the Chesapeake Bay, where nutrient load reduction is a major basin goal for the Bay. Therefore, limiting the nutrient loads from Watts Branch will assist in achieving the larger basin goal of the Chesapeake Bay.

In response to the water quality goals of the project, stormwater retrofits that provide both channel protection and water quality benefits were pursued as one of the tools of the Watts Branch watershed management plan. Stormwater retrofit and stream rehabilitation inventories were conducted throughout the watershed to identify candidate sites. The Center and ESA worked with staff and the Partnership to develop ranking systems, which accounted for benefits and associated costs or undesirable effects. The stormwater management (SWM) ranking system used a two-tiered method which compared technical or watershed issues, such as size of drainage area, site availability and utility conflicts, maintenance burdens, efficiency at providing water quality and quantity, and unit costs, against environmental and community goals, including wetland, tree and recreational use impacts, and a community acceptance factor. Stream rehabilitation projects were similarly ranked with a system comparing the length and severity of the erosion against forest impacts from construction and site ownership. Several variations on each ranking system were tried to give the Partnership different ways of evaluating the projects. Using these ranking systems, sites were prioritized and selected to be carried forward in the design process (Phase II of the project).

A total of 54 candidate stormwater retrofits sites were originally identified and field investigated to verify technical feasibility and to identify the most likely management practice for each site. Seventeen of the 54 candidate sites were abandoned after the field screening for a variety of reasons, including inadequate space for effective SWM or retrofits already being provided by private development (such as Fallsgrove). Of the remaining 37 sites, the 18 top-ranked candidate sites were identified by the ranking systems for further investigation through the development of detailed conceptual designs (Phase II). Subsequent to the submittal of the detailed conceptual designs and public review and comment, an additional three SWM candidate sites were eliminated from further consideration at this time, and one site, Aintree SWM Pond, is being assessed independent of the watershed study process. This results in 14 SWM sites as priority implementation projects for the watershed study.

Similarly, 62 RSAT locations, covering 4.7 miles of Watts Branch mainstem and tributaries, were identified as candidates for stream rehabilitation. The stream rehabilitation site evaluation narrowed this down using the ranking system and grouping adjacent candidate sites. The prioritization process identified 35 separate stream rehabilitation project sites that went forward to the design concept stage (Phase II), resulting in twelve distinct stream projects, or protection for 2.7 miles of stream.

E.3 Recommendations

While all 14 retrofit and twelve stream rehabilitation sites are valid candidates for further investigation and design (see Figure E.2), the reality is that fiscal and staff resources limit the number of projects that can be implemented in a timely fashion. In addition, it is most appropriate to implement projects that complement each other and limit the overall disturbance of existing natural resources as much as possible. It is therefore important to try to prioritize the implementation of these projects in a subwatershed context. In other words, sites that should be pursued first should be pursued in the context of the overall benefit to the watershed through a subwatershed management strategy and an approach that seeks to combine stormwater retrofits with other rehabilitation strategies.

As part of Phase II, three parameters were evaluated to identify subwatersheds for high priority implementation: the current condition of riparian buffer within each subwatershed, the distribution of stormwater retrofits across the watershed as a whole, and the relative proximity of recommended stream rehabilitation sites downstream from recommended retrofit sites. Table E.1 lists the subwatersheds recommended for priority implementation. Figure E.2 shows the locations of the prioritized subwatersheds. It should be noted that there are additional considerations that may ultimately shift the priority implementation such as the efficiency of coordinating with other public works projects (e.g., sewer repairs and improvements), community issues and concerns (e.g., severe erosion correction and/or park program considerations), and wetland and forest area improvements.

Table E.1 Recommended Subwatershed for Priority Implementation

Subwatershed Designation	Recommended Projects for Implementation	Justification
204	Stormwater retrofits: SM-18, SM-19 & SM-20 Stream rehabilitation sites: 204-5; and 302-12 to 204-1[1]	combines retrofits with downstream stream rehabilitation, and consolidates construction disturbances
205	Stream rehabilitation sites: 205-5 to 205-8; & 302-12, 205-1 to 205-2[2]	combines upstream stormwater management (King Farm) with downstream stream rehabilitation, and consolidates construction disturbances
114 & 115A	Stormwater retrofits: O-3, SM-23 and SM-22* Stream rehabilitation sites: 115A-1 to 115A-3; & 302-3, 302-4 to 302-8[3]	combines retrofits with downstream stream rehabilitation, and consolidates construction disturbances
119	Stormwater retrofits: SM-1, SM-2, and SM-3	downstream retrofits that provide water quality and channel protection treatment for the majority of the subwatershed
103	Stormwater retrofits: SD-8 and SD-6 Stream rehabilitation sites: 103-5 to 103-8; & 103-1 to 103-2[4] Riparian buffer enhancement	combines retrofits with downstream stream rehabilitation, buffer enhancement, and consolidates construction disturbances
Mainstem	Stream rehabilitation sites: 401-15 to 401-18, 401-8 to 401-11, 401-3 to 401-3, 401-5 to 401-6	combines upstream retrofits with stream rehabilitation to stem significant erosion and protect City sewer infrastructure

Notes:
* It is acknowledged that site SM-22 is privately owned. The City should work diligently with the owner to pursue this project.

Option 1 Stream rehab. for site 204-1 would be combined with SM-20 to minimize construction disruptions

Option 2 Stream rehab. for site 205-1 & 205-2 combined as one reach with sites 302-12 to 204-1

Option 3 Stream rehab. for site 115A-1 to 115A-3 combined as one site with 302-3 to 302-6 to link disturbed areas and minimize construction disruptions

Option 4 Stream rehab. at site 103-1 & 103-2 would also include sites 401-15 to 401-18 to link disturbed areas and minimize construction disruptions

Subwatershed 204, while having among the best current riparian cover, also contains three important stormwater retrofit sites (SM-18, 270-Industrial Park Pond; SM-19, PEPCO Site Pond; and SM-20, Carnation Drive Pond) with the capability to substantially control a significant portion of the runoff from the contributing subwatershed. These three sites coupled with implementation of stormwater management on the King Farm, are upstream from three of the recommended stream rehabilitation sites (site 204-5, 204-1, and 302-12, downstream from SM-18, SM-19, & SM-20). Subwatershed 205 also has excellent riparian cover and has upstream stormwater management provided on King Farm. Consequently, it is recommended to pursue stream rehabilitation sites 205-5 to 205-8, 205-1 to 205-2 and site 302-12 (this site is downstream to subwatershed 204 and 205) as connected projects after SWM improvements are made upstream.

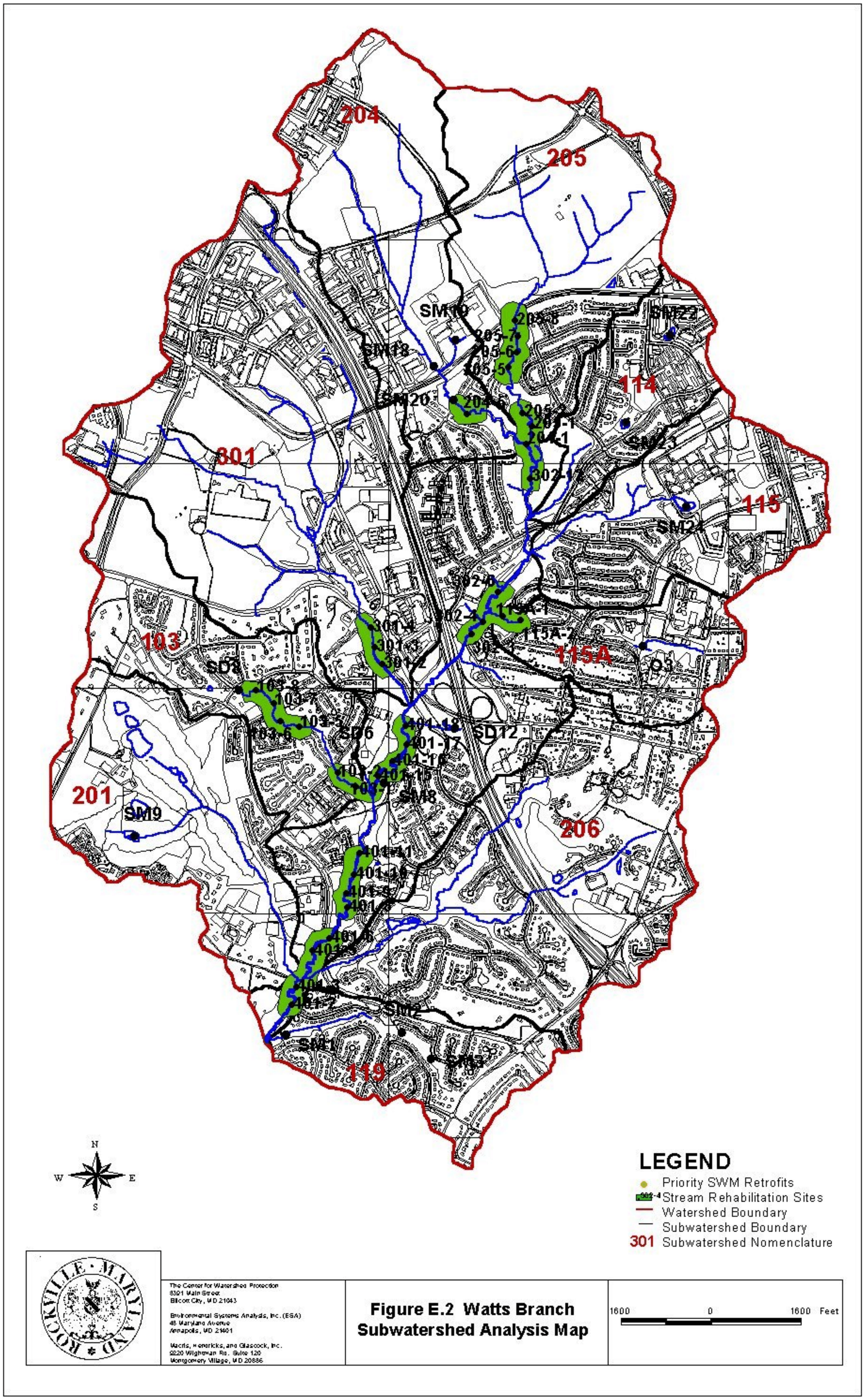
Subwatershed 114, which contains College Gardens, is the most impervious subwatershed in the study and it contains virtually no stormwater management controls (neither water quantity nor water quality control). SWM Retrofit site SM-23, College Gardens Park Pond, provides an opportunity to control and treat a portion of the runoff from this subwatershed, which should also benefit priority downstream rehabilitation sites. Finally, there is a direct link in subwatershed 115A where site O-3 (Welsh Park Pond) drains to the storm drainpipe leading to the eroded outfall channel at site 115A-1 to 115A-3, where stream rehabilitation is proposed. Just below and above the confluence with the Watts Branch mainstem (tributary 302) is another stream rehabilitation site (302-3, 4 & 6). When combined with the upstream retrofit project and the stream rehabilitation work in subwatersheds 115A and 114, it makes sense to consolidate the construction in this area. In addition, stream rehabilitation site 302-3 to 302-6 will receive some benefits from upstream retrofit sites in subwatersheds 204 and 205.

Subwatershed 119, the Horizon Hill community, has an opportunity to provide both water quality and channel protection storage for almost the entire subwatershed through upgrades to the three existing SWM ponds at SM-1, SM-2 and SM-3. This will provide protection to the wooded section of tributary below the most downstream pond, and to the mainstem below Horizon Hill tributary. There are no stream rehabilitation sites associated with this priority subwatershed since much of the stream valley within Horizon Hill Park was previously stabilized by the City, and the SWM retrofits should adequately protect the downstream channel.

Subwatershed 103 contains the SWM retrofit sites SD-8 (Glenora Park) and SD-6 (Woottons Mill Park), and two stream rehabilitation segments (sites 103-1 to 103-2 in Woottons Mill Park; and 103-5 to 103-8 below Glenora Park). Based on the amount of existing severe channel degradation, the potential for partial control of channel-forming storm events, and the potential for riparian buffer enhancement, it is our recommendation that subwatershed 103 be carried forward as a priority site.

Woottons Mill Park is experiencing significant erosion along the mainstem of Watts Branch, and has extensive stream rehabilitation proposed. Stream protection is vital along these reaches because of the large volume of runoff from many neighborhoods that have no SWM opportunities. The City's Watts Branch sanitary sewer trunk line, which parallels the mainstem, has been exposed in several locations. The Department of Public Works intends to stabilize these eroded reaches and repair the sewer manholes and lines before more serious damage occurs to the sewer line. Therefore, the stream rehabilitation projects from 401-8 to 401-11 and 401-15 to 401-18 are also listed as priority in the City's Implementation Schedule, although they are not part of a particular subwatershed.

Figure E.2 Subwatershed Analysis Map



E.4 Watershed Education and Pollution Prevention Strategy

In addition to the structural recommendations, a series of pollution prevention measures and public education approaches are recommended in the Watts Branch Watershed Management Plan (Phase III of the project). Pollutant load reduction is always more effective when controlled at the source (i.e., yards, parking lots, parks) rather than trying to treat the runoff after the fact. Pollution prevention program success starts with educating the public about watershed awareness and the importance of an individual's behavior on the health of a watershed. An effective and widespread pollution prevention program coupled with the water quality benefit of the stormwater retrofits should help meet the water quality goals of the Watts Branch watershed as well as the Potomac River and Chesapeake Bay. It will be easier and more efficient for the City to develop a city-wide program rather than limiting it to Watts Branch watershed alone; the staff has therefore recommended that this component be developed and implemented separately from the watershed study projects. The City's Environmental Specialist will have the greatest role in managing this new program. Table E.2 presents program recommendations for the City to consider.

Table E.2 Nonstructural Pollution Prevention Program Recommendations

Program Recommendation	Program Components
Watershed Awareness	• Promote general awareness and responsibility of citizens with respect to being good stewards to their watersheds • Encourage and promote citizen activities around watersheds such as monitoring, tree plantings, "green-up" days, water conservation, clean ups and policing (e.g., reporting illegal dumping)
Pet Waste Management	• Signage and waste disposal stations • Fact sheets and limited media campaign
Lawn and Garden Care, Landscaping (Bay Scapes)	• Promotion of soil testing through Montgomery College • Recognize citizens using proper practices • Garden club and nursery outreach and education
Automotive Care (Car Washing and Maintenance)	• Promotion of washing on pervious surfaces and with minimum amounts of water • Proper disposal and recycling of used motor fluids
Good Housekeeping	• Promotion of proper disposal and/or recycling of household and commercial hazardous wastes
Disconnection of Directly Connected Impervious Areas	• Institute downspout disconnection and rain barrel program
Illicit Connection Detection and Removal	• Monitor and eliminate illicit connections in targeted commercial areas
Commercial Dumpster Management	• Locate away from storm drain inlets and riparian buffers • Promote/require use of enclosed holding areas

E.5 Watershed Indicator Monitoring

Having a method to assess the efficacy of the implemented measures and a basis from which to recommend modifications to the plan is a critical piece to the overall plan. A goal of the Center's recommended watershed management plan approach is to utilize stormwater indicators to the maximum extent practical to guide current and future management decisions (Phase III of the project). The recommendations are oriented towards conducting inexpensive, repeatable, and scientifically valid monitoring to assess future stream quality health. The monitoring of indicators will provide a key frame of reference and basis for updating and adjusting the Watts Branch Watershed Management Plan.

A suite of six indicators (Table E.3) have been identified and recommended to assess the efficacy of the Watts Branch Watershed Management Plan. As part of this project, baseline macroinvertebrate and fish data will be collected during the spring of 2001. These data will provide a benchmark from which to measure various aspects of the proposed management plan.

Table E.3 Stormwater Indicator Profile Categories

Indicator Category	Indicator Name
Physical and Hydrological Indicators	• Stream widening/downcutting • Physical habitat monitoring
Biological Indicators	• Macroinvertebrate and fish assemblage
Social Indicators	• Public attitude surveys • Public involvement and monitoring • User perception

E.6 Implementation

Throughout the development of the Watts Branch Watershed Management Plan, the City of Rockville Department of Public Works has been evaluating and planning an implementation schedule for the priority projects. This planning has included budget considerations for the Capital Improvement Projects (CIP) list, need for other work in the Watts Branch stream valley such as sewer line rehabilitation, and concurrent scheduling for improvements approved in the Cabin John and Rock Creek watershed studies. Based on current budget planning and projections, the recommended projects which are City-owned or operated are slated for a staggered implementation over the next 10-year period. The City has started, and will continue to work with owners of private sites where watershed improvements have been recommended to facilitate those projects through the normal development process, environmental grant or public agency programs.

The City recognizes the conceptual nature of the recommended stormwater management and stream restoration projects in the management plan, which are subject to change in the final design phase. All of the proposed watershed improvements will require more detail and attention at the final design stage to minimize construction disruption and address residents' concerns. Staff and the design consultants will work with community members throughout final design, and will gather residents' ideas for improving projects and incorporate them where feasible. the following design guidelines, among others, will be considered:

- There will be flexibility in stormwater management design, layout and size to help resolve residents' concerns with loss of recreational space in local parks;
- Stormwater management design details will be reviewed to promote safety, attractiveness and softening of the manmade structures visible in the ponds;
- Staff will seek opportunities to reduce stormwater management pond footprints if alternate cost-effective stormwater management choices become available to offset the storage loss;
- Staff will consider each park as a whole as well as evaluating the effect of watershed projects upon the immediate area to be disturbed.

SECTION 1. INTRODUCTION

This report provides a summary of the findings from a three phase project for work related to the Watts Branch Watershed Study and Management Plan project. Phase I of the project was largely devoted to data collection and analysis of both historic and existing conditions. In Phase II, the project team prepared conceptual designs, cost estimates and analyses of estimated benefits for specific watershed management measures such as stormwater management retrofits, stream rehabilitation, wetland enhancement, and forest conservation. In Phase III, the final phase, the project team developed management recommendations for public outreach and education, bench mark and long term monitoring, and prioritization of implementation. Recommendations have been formulated with respect to watershed management approaches aimed at reducing and mitigating many of the adverse impacts that the watershed has experienced over the course of urbanization. The major sections of this report include:

- Introduction and Background
- Current Watershed Conditions
- Stormwater Retrofit Opportunities
- Stream, Wetland, and Forest Rehabilitation Opportunities
- Watershed Management, Public Outreach and Education, and Watershed Indicator Monitoring Recommendations

1.1 Why Watersheds?

Urbanizing communities frequently find that their water resources are degrading in response to growth and development. They are also discovering that they can only protect these local water resources by thinking on a watershed level. Watersheds are important to any community because they embody our sense of place in the landscape, and their waters are important in our daily life. Some of the many interactions between ourselves and urban watersheds are described below in Table 1.1. In an important sense, watersheds are the geographic address for our community, and provide a common and unifying goal to rally around.

Table 1.1 Some of the Important Aspects of Watersheds and Urban Streams

In Our Daily Life	Where We Recreate	In the Natural Ecosystem
drinking water	fishing	food chain
food (shellfish, fish)	swimming	habitat
kids playing in creek	boating	migratory stop-overs
property drainage	hiking trails and greenways	
flooding and erosion	bird watching	

Communities find many reasons to protect local watersheds--whether it is because of economic benefits, recreation, flood prevention, scenery or the overall quality of life. Different groups of people often have their own unique rationale for protecting watersheds. Some may place a high value on the aquatic biological community living in these waters, while others will be more concerned about reducing stream channel erosion to the real estate in their back yard. Regardless of the reasons, it is clear that most communities now recognize the value of local watershed protection. Watts Branch is no different in this sense. The Watts Branch watershed serves as an important focal point and community attraction for the City of Rockville. With its established park land, recreational centers, and foot trails, the watershed provides both active and passive recreational opportunities. However, with development that has occurred over the last 40 to 50 years in the watershed, increasing pressure has been placed on this resource. In many locations, the stream has eroded and degraded to the point where habitat and recreational functions have been severely limited or altogether lost.

The primary objective of the Watts Branch watershed project is to develop a comprehensive watershed rehabilitation and protection plan that will establish an implementation program aimed at mitigating many of the impacts and stresses that exist on the ecosystem. Through implementation of the proposed mitigation measures, it is hoped that many of the existing benefits associated with the watershed will be protected and that many of the lost or impaired uses will be restored to both the natural and built environment. Specific watershed protection goals of the plan include:

- Minimize/control channel enlargement (i.e., channel erosion)
- Reduce pollutant loadings from nonpoint source runoff
- Develop stewardship among residents by educating and changing behaviors and building interest in the watershed
- Protect existing utilities in and near streams from erosion damage
- Provide effective stormwater management control over a significant proportion of the watershed (or subwatershed)
- Protect existing forest areas
- Protect existing wetlands
- Protect existing active recreational areas

Watershed management often must balance competing interests to achieve a net environmental benefit for the watershed. This study attempted to accomplish this by objectively weighing the various recommendations and opinions offered during the planning process. In the end, the management plan and priority recommendations reflect a process of consensus building and compromise reaching that has strived to optimize the ability to meet the watershed goals while causing the minimum amount of disruption.

1.2 Rockville's Stormwater Management Program

The City of Rockville began its stormwater management program for new development in 1978. Today, the City requires all new development to meet recently adopted state guidelines for water quality and quantity treatment. The City's Stormwater Management law (Chapter 19 of the City Code) and the Department of Public Works' Stormwater Management Regulations describe the requirements for new development, which is administered through the City's development review and permitting process. Smaller projects may qualify to use the City's Regional stormwater management Participation program in lieu of on-site stormwater management facilities, if on-site stormwater management is impractical or infeasible. The Regional Participation Program accepts off-site stormwater management, stream improvements or monetary contributions which help the City provide public watershed improvements throughout the City.

The watershed management plans are intended to address current deficiencies in stormwater management and stream protection caused by previous development. The Watts Branch Watershed Management Plan is the third done by the City for its watersheds. The Cabin John Watershed Study, covering southern Rockville, was adopted in 1995, and a number of the recommended stormwater management facilities and stream restoration projects have been implemented. The Rock Creek Watershed Management Plan, adopted in 2000, recommended mostly stream restoration projects for the highly urbanized eastern part of Rockville, although stormwater management retrofits were included where space was available.

The Department of Public Works is responsible for watershed studies, stormwater management, correction of stream erosion problems, and storm drain conveyance, in addition to the public water, sewer and road infrastructure in the City. The City implements public watershed improvements through the Capital Improvements Program with money from the Stormwater Management Fund. The same mechanism is used to provide inspections and maintenance for existing public stormwater management facilities.

1.3 Watershed Characterization and History of Development Patterns in Watts Branch

It is helpful to have a general understanding of some of the major characteristics of the Watts Branch watershed (e.g., size, location, population, land use, percent impervious, etc.) to help provide context for the technical analyses and management recommendations presented in subsequent sections of this report. The following discussion provides background information on key watershed characteristics as well as a chronological summary of development in the watershed.

Watts Branch is an approximately 22 square mile tributary to the Potomac River (see Figure 1.1). The confluence of the Potomac River and Watts Branch is of particular importance due to the fact that it is just upstream of a major Washington Suburban Sanitary Commission drinking water intake for suburban Maryland; consequently, the water quality of Watts Branch can have a significant impact on the level of treatment required at the drinking water plant. Historic observations have indicated that during and just after storm events, a higher level of treatment than normal is required at the plant due to the increased sediment load from Watts Branch (and possibly other nearby upstream tributaries). Watts Branch is also tributary to the Chesapeake

Bay, where nutrient and sediment load reduction is a major basin goal for the Bay. In fact, last June, the Chesapeake Executive Council (which includes the governors of Maryland, Pennsylvania, Virginia, the District of Columbia Mayor, the EPA administrator and Chesapeake Bay Commission chairman) signed the Chesapeake 2000 Agreement, which calls for cleaning up the Bay by 2010. To do that, new nutrient (and, for the first time, sediment) goals will be set by the end of 2001. The cleanup gained urgency in 1999, when the EPA placed the Bay on its list of “impaired” waters because it does not meet water quality standards that support the needs of those “living resources.” Unless it attains those standards by 2010, the region will have to develop a detailed, enforceable cleanup plan known as a Total Maximum Daily Load (TMDL) (ACB, 2001). Therefore, limiting the nutrient loads from Watts Branch will assist in achieving the larger basin goal of the Chesapeake Bay.

The Watts Branch watershed within the City of Rockville is approximately 6.5 square miles, and includes the vast majority of first and second order streams in the watershed as a whole. A stream reach numbering convention was established to facilitate the rapid field assessments that were conducted as well as the analysis of smaller subwatersheds. The numbering convention used to identify reaches is based on the order of the stream (e.g., first order through fourth order). For example, there is one fourth order reach consisting of the main stem of Watts Branch (i.e., 401), two third order reaches (i.e., 301 and 302) also considered as the main stem, six second order reaches and so on. Stream reaches were numbered in a clockwise direction starting at the most downstream point and starting with first order streams. For subwatershed analysis, the numbering convention used is based on the highest (i.e., largest) order stream within the delineated subwatershed. For example, the southwestern most subwatershed is comprised of stream reaches 101, 102, and 201. Therefore, the subwatershed identification number is 201. A total of ten subwatersheds were delineated for subwatershed analysis. Figure 1.2 illustrates these naming conventions for the reaches and subwatersheds and Table 1.2 provides a summary of some key subwatershed characteristics.

Figure 1.1 Vicinity Map for Watts Branch Watershed (Source: Microsoft™ Expedia Streets 98)

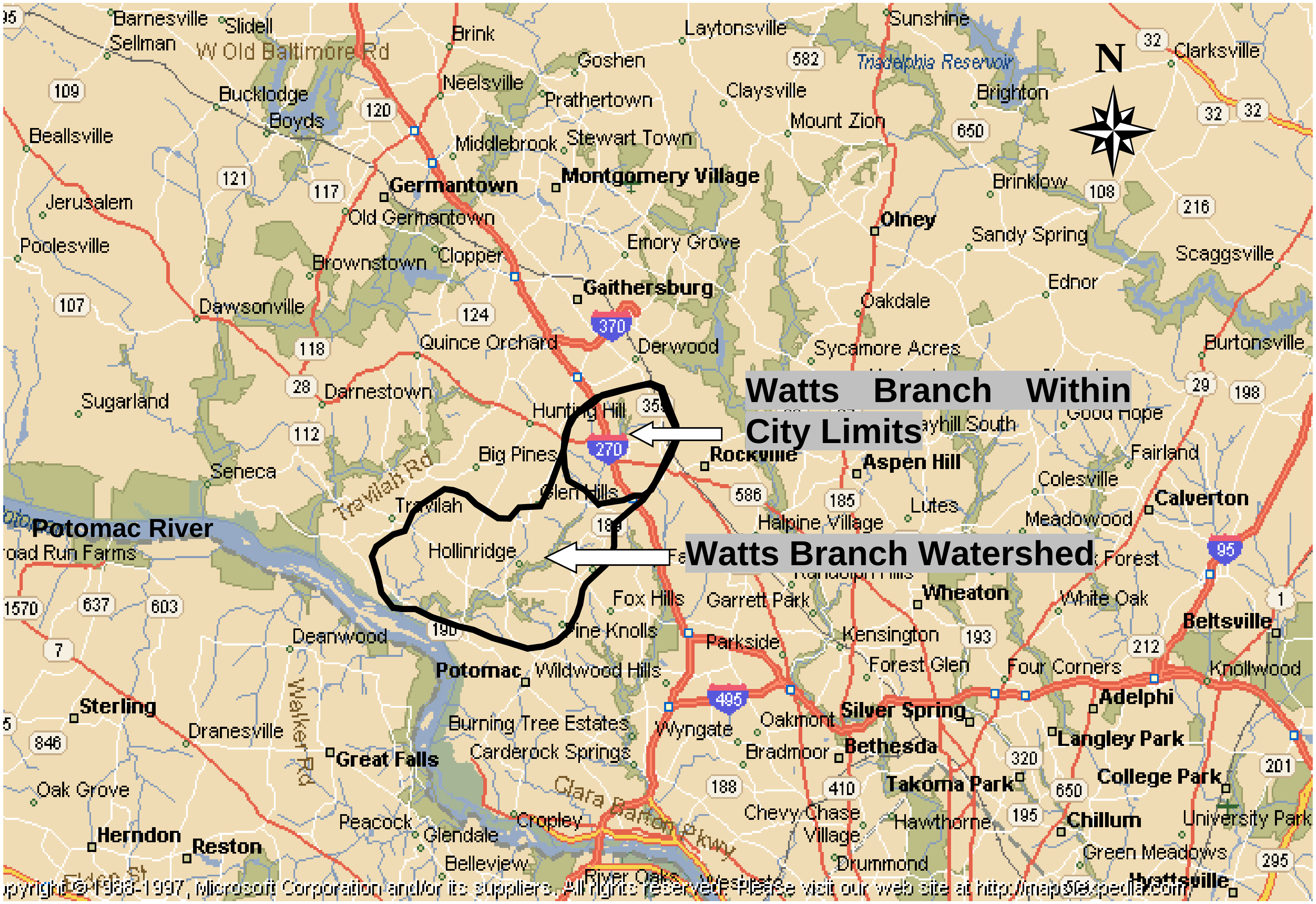


Table 1.2 Watts Branch Subwatershed Characteristics

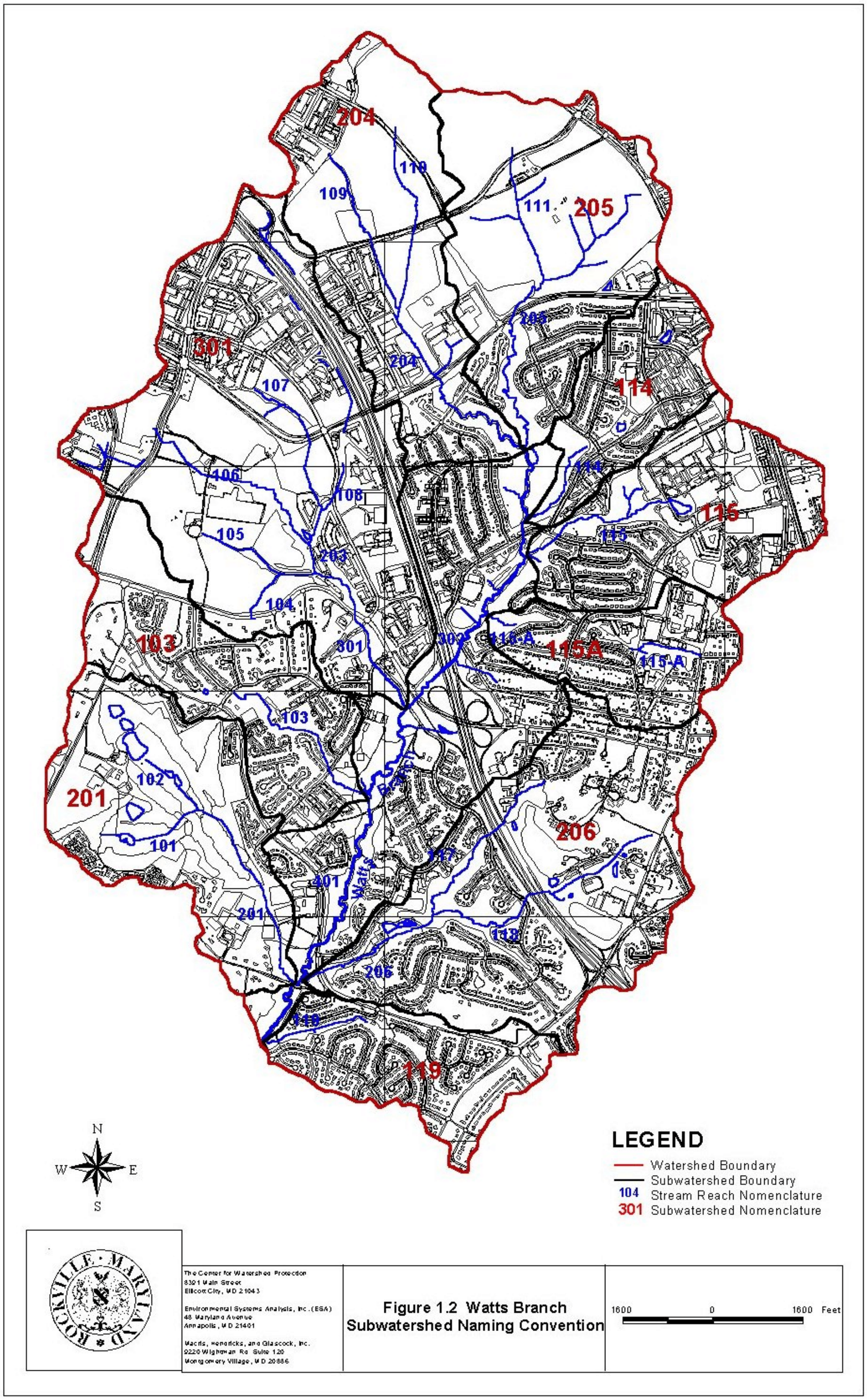
Subwatershed ID	Area (Acres)	Stream Miles	Approx. Imp. Cover (%)	Predominant Land Use
201	336	1.4	20	institutional, golf course
103	285	0.7	30	medium density residential
301	735	4.1	25	agricultural, office/commercial
204	389	2.3	30	office/commercial, residential
205	407	2.5	30	residential, mixed use
114	159	0.4	50	high/med. density residential
115	283	0.8	30	med. density res., institutional
115A	165	0.9*	30	med. density res., institutional
206	540	2.2	28	med. density res., institutional
119	184	0.4	28	medium density residential
Mainstem	677	3.5	28**	residential, mixed use

* Includes approximately 0.5 miles of piped channel
** Estimated based on visual inspection and comparison with other subwatersheds

In general, the mainstem of Watts Branch flows from north to south. The current (i.e., 1999) imperviousness of the Watts Branch watershed within the City of Rockville limits is approximately 28 percent. Based on the management classification scheme developed by the Center for Watershed Protection (1998), Watts Branch falls into the “Non-supporting” or “Restorable” watershed categories. This is important in that it helps define realistic expectations of what current watershed conditions are as well as what the prospects are for improvement in response to mitigation and rehabilitation efforts.

Of the approximately 18.7 miles of stream within the City, roughly 37% or 7 miles lie within City Department of Recreation and Parks ownership. This fact demonstrates the importance of working closely with the Recreation and Parks department to achieve multiple objectives with proposed retrofits and stream restoration projects and for working towards an efficient implementation plan.

Figure 1.2 Watts Branch Subwatershed Naming Convention



Existing water quality and macroinvertebrate data tend to support the classification of Watts Branch as “Non-supporting” or “Restorable” stream. A 1997 report by EA Engineering Inc. summarizes the available historic water quality and macroinvertebrate data for Watts Branch. Watts Branch water quality is characterized as good to excellent in the early 1970s; however, by the mid to late 1990s, the data reflect fair to poor water quality. Of particular note is the observed decline in water quality in the upper reaches of Watts Branch, possibly attributed to agricultural runoff and subsequent development of the King Farm parcel, Piccard Drive office buildings, and I-270 widening. Similar to the water quality data, the existing benthic macroinvertebrate data suggest that there has been a general decline in the diversity and richness of species, with most recent sample points being described as poor.

A factor contributing to the declining water quality and macroinvertebrate community in the Watts Branch watershed is urbanization (see discussion in Section 1.5). With the current and planned development of the last two significant parcels of contiguous land (King Farm and Thomas Farm), the Watts Branch watershed will be essentially built-out. The land use within the watershed is comprised of a mixture of residential, commercial, and institutional. Of these, the predominant land use is single family residential (see Figure 1.3).

The development patterns in Watts Branch over the last century can be roughly broken out into the following five eras during which notable trends occurred or specific areas were targeted for buildout:

- Pre World War II
- Post World War II - 1960
- 1960 - 1970
- 1970 - 1990
- 1990 - present

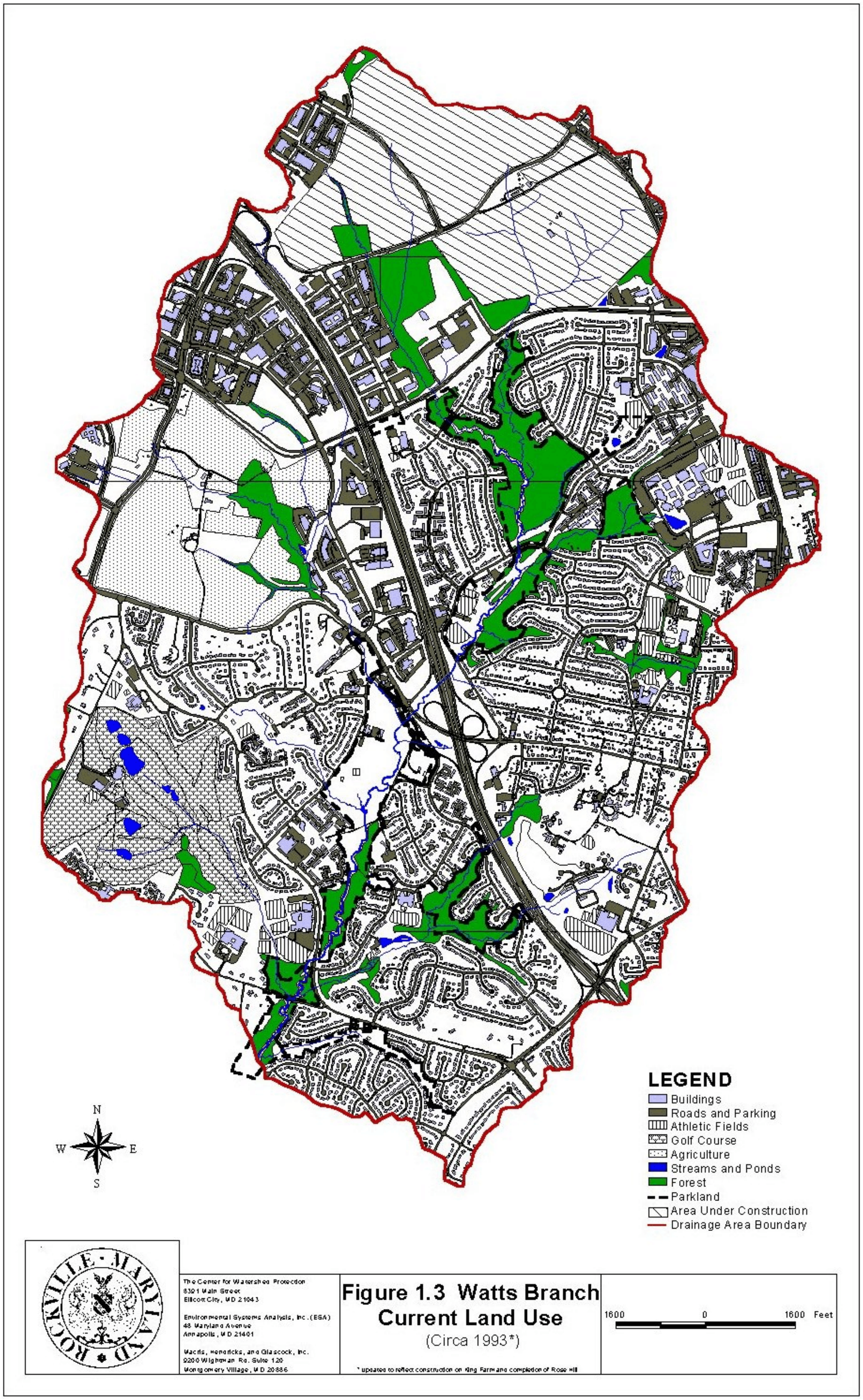
Pre World War II

Development prior to World War II was generally limited to the West End (the W. Montgomery Avenue corridor and nearby vicinity). Much of this development dated to the Victorian era (c. 1870 - 1890). The land use prior to World War II was predominantly agriculture and forest.

Post World War II - 1960

Post World War II development saw the construction of much of the Woodley Gardens project. With these residential areas came construction of sanitary sewer trunk mains along/parallel to Watts Branch. Major transportation projects were also built in this era, with the original construction of I-270 (circa 1957-1959) as a 4-lane interstate with two interchanges, one at Rt. 28 (near the mainstem of Watts Branch) and the other at Shady Grove Road (at the northern watershed boundary near the headwaters of Watts Branch). It is also of note that an effort was made to preserve large contiguous tracts of forest cover and park lands along and adjacent to the mainstem of Watts Branch (e.g., Woodley Gardens Park) during this era.

Figure 1.3 Watts Branch Current Land Use



1960 - 1970
During the 1960s, additional residential development occurred northeast of I-270 and north of Watts Branch in College Gardens and in an area known as Rockville Estates, now considered part of Woodley Gardens. Similar to the previous era, this development occurred without consideration of stormwater management. Additional commercial development also occurred with construction of office parks on either side of I-270 along Piccard Drive and Research Boulevard.

1970 - 1990
This era showed the advent of early stormwater quantity management, with single family residential development southwest of I-270 in the Rockmead, Rockshire, and Fallswood areas. In addition, office park development continued along Piccard Drive and Research Boulevard. Major transportation projects included construction of the first part of Wootton Parkway in the early 1970s and widening of I-270 to 12 lanes and the addition of a third interchange within the Watts Branch watershed at Falls Road. Basic erosion and sediment controls and stormwater management controls were implemented during this era.

1990 - present
In the last decade, development has consisted of small infill projects as well as planning of the last two significant parcels of farm land, King Farm and Thomas Farm (renamed Fallsgrove). These parcels are or will be developed as mixed use parcels. In addition, transportation-related projects have included the widening of Rt. 28 and the extension of Key West Avenue. Once development of the Fallsgrove and King Farm parcels is complete, the Watts Branch watershed will essentially be fully built-out and urbanized.

At the same time of this study's field work in 1999, major development activity included construction at King Farm on Phases 1, 2, and 3; mass grading at King Farm started in 1996. The Rose Hill residential construction was also underway in 1999. Fallsgrove did not break ground until 2000, after this study's field work was concluded.

1.4 Watts Branch Geomorphic History

The Watts Branch watershed is somewhat unique in that it is a rare example of a watershed that has been scientifically studied over time. The renowned fluvial geomorphologist, Dr. Luna Leopold, had the foresight to study the Watts Branch watershed in an attempt to establish a database from which to track and analyze changes in small headwater stream channels. At the outset, Leopold believed that the results of his work would be of interest to the generation of his grandchildren. He quickly realized, however, that the changes he observed occurred far more rapidly than he had expected (Leopold, 1973).

Leopold surveyed approximately 14 monumented cross sections along the main stem of Watts Branch in the vicinity of Woottons Mill Park every other year over a 20 year period (1953-1972). Figure 1.4 is a photograph of the area studied in the late 1950s. As can be seen, this reach of Watts Branch was largely in an agricultural setting.

Figure 1.4 Historic photo (circa late 1950s) of Leopold investigation site

The initial purpose of Leopold's investigation was to describe the process and rate of lateral migration of the stream channel, the construction of point bars and flood plain, and the effects of meander curves on the process and rate of migration. An unintended result of Leopold's research was quantitative data on the effects of progressive urbanization in a small watershed (the contributing drainage area to the majority of Leopold's study points was approximately 3.7 square miles). During the first decade of observation, Leopold noted a decrease in channel cross sectional area. He attributed this, in part, to the sediment being generated and deposited from upstream urbanization. As the urbanization within the watershed intensified in the 1960s (coinciding with Leopold's second decade of observation), the channel reversed its form, going from contraction to enlargement.

As this report documents, the enlargement trend that Leopold observed in Watts Branch has continued through the 1990s, and can be directly related to the degree and rate of urbanization. The adverse impacts associated with the channel enlargement are a major reason for this watershed planning effort. Having access to Leopold's detailed, historic data provides an important validation for the analyses performed as part of this project.

1.5 Impacts of Urbanization and the Influence of Impervious Cover on Stream Quality

The process of urbanization has a profound influence on the hydrology, morphology, water quality, and ecology of surface waters. Impervious cover is an important indicator with which to measure the impacts of land development on aquatic systems. Numerous scientific studies have documented the relationship between impervious cover and overall stream health. Much of the technical analysis performed for this watershed project uses impervious cover directly or indirectly to quantify and develop specific mitigation strategies for both instream rehabilitation efforts and stormwater management retrofit conceptual design.

The discussion presented below provides specific detail about some of the key changes in urban streams due to increases in impervious cover levels.

<u>Surface runoff during storm events dramatically increases</u>. Depending on the degree of impervious cover, the annual volume of stormwater runoff can increase by 2 to 16 times its predevelopment rate, with proportional reductions in groundwater recharge (Schueler, 1994). Research by Leopold (1994) shows that the average annual flood increased from 781 cfs during the period of 1958-1973 to 959 cfs during the period of 1973-1987. This represents a 23 % increase in peak discharge.

<u>Bankfull and sub-bankfull floods increase in magnitude and frequency</u>. The peak discharge associated with the bankfull flow (i.e., the 1.5 to 2 year return storm) increases sharply in magnitude in urban streams. In addition, channels experience more bankfull and sub-bankfull flood events each year, and are exposed to critical erosive velocities for longer intervals (Hollis, 1975; Booth *et al.*, 1996; and MacRae, 1996). Leopold (1973) found that over a 12 year period from 1958-1969, the frequency of flows exceeding the Watts Branch channel capacity increased by roughly a factor of 4 and that the frequency of large out of bank events (i.e., 1,000 cfs) increased dramatically as well.

<u>Channels enlarge</u>. The customary response by an urban stream is to increase its cross-sectional area to accommodate the higher and more frequent erosive flows. This is done by stream bed down-cutting, stream bank widening, or a combination of both. Urban stream channels often enlarge their cross-sectional area by a factor of two to ten, depending on the degree of impervious cover and the age of development in the upland watershed (Caraco, 2000; Arnold *et al.*, 1982; Gregory *et al.*, 1992; and MacRae, 1996).

<u>Stream channels are highly modified by human activity.</u> Urban stream channels are extensively modified in an effort to protect adjacent property from streambank erosion or flooding and to cross the streams with bridges and culverts. Headwater streams are frequently enclosed within storm drains, while others are channelized, lined, and or "armored" by heavy stone. Another modification that is unique to urban streams is the installation of sanitary sewers underneath or parallel to the stream channel. According to May, *et al.* (1997), 20 to 30% of natural stream channels are modified in typical urban watersheds.

<u>Instream habitat structure degrades</u>. Urban streams are routinely scored as having poor instream habitat quality, regardless of the specific measure or method employed. Habitat degradation is often exemplified by a loss of pool and riffle structure, embedding of stream substrate sediments, shallow depths of flow, eroding and unstable banks, and frequent stream bed dislocation.

Stream crossings and potential fish barriers increase. Many forms of urban development are linear in nature (e.g., roads, sewers, and pipelines) and cross stream channels. The number of stream crossings increases directly in proportion to impervious cover (May *et al.,* 1997), and many crossings can become partial or total barriers to upstream fish migration, particularly if the stream bed erodes below the fixed elevation of a culvert or a pipeline. On the Watts Branch mainstem alone, there are at least eight major crossings. Many more exist on the tributaries.

Riparian forests become fragmented, narrower and less diverse. The important role that riparian forests play in stream ecology is often diminished in urban watersheds, as tree cover is often partially or totally removed along the stream as a consequence of development (May *et al.*, 1997). Even when stream buffers are reserved, encroachment often reduces their effective width, and native species are supplanted by exotic, non-native trees, vines and ground covers.

Water quality declines. The water quality of most urban streams during storm events is consistently poor. Urban stormwater runoff contains moderate to high concentrations of sediment, carbon, nutrients, trace metals, hydrocarbons, chlorides and bacteria (Schueler, 1987). While considerable debate exists as to whether stormwater pollutant concentrations are actually toxic to aquatic organisms, researchers agree that pollutants deposited in the stream bed exert an undesirable impact on the stream community.

Reduced aquatic diversity. Urban streams are typified by fair to poor fish and macroinvertebrate diversity, even at relatively low levels of watershed impervious cover or population density. The ability to restore pre-development fish assemblages or aquatic diversity is constrained by a host of factors: irreversible changes in carbon supply, temperature, hydrology, lack of instream habitat structure, and barriers that limit natural recolonization. Watts Branch confirms this generalization as exhibited by monitoring results from Montgomery County's Stream Protection Strategy (CSPS). Specifically the 1996 data report "fair" (based on a scale of excellent, good, fair, and poor) fish diversity and fair to poor macroinvertebrate diversity.

1.6 Rapid Watershed Approach

Because impervious cover is a good indicator of stream health, coupled with the fact that it is a parameter that is fairly easy to measure on a watershed basis, it is a good management tool in the watershed planning and protection process. Under the rapid watershed planning approach advocated by the Center, the impervious cover model is used to provide a preliminary diagnosis of stream health along with a suite of management options based on realistic expectations of what can be achieved in a given watershed. The model identifies three general stream types based on impervious cover ranges and offers general recommendations for planning goals and objectives. The three stream types are: sensitive streams (0-10% imperviousness); impacted streams (11-25% imperviousness), and non-supporting streams (>25% imperviousness). A fourth designation is given to impacted or non-supporting streams for streams that have potential to be restored/rehabilitated to the next best classification level (e.g., move from a non-supporting designation to an impacted designation). The reader is referred to *Rapid Watershed Planning Handbook* for a more detailed discussion of the impervious cover model (CWP, 1998).

Using rapid watershed diagnostic techniques such as the impervious cover model and other field assessment protocols (e.g., The Rapid Stream Assessment Technique and The Rapid Geomorphic Assessment) translates into time and money savings that facilitates more rapid implementation of management strategies.

The rapid approach is in contrast to how many past watershed planning efforts have occurred. All too often, communities find that some of their past watershed planning efforts have not always protected local water resources adequately, i.e, measurably reduced the cumulative impacts of watershed development over the long run. The failure of many watershed planning and implementation studies can often be attributed to factors such as:

- **Plan is conducted at too great a scale –** the focus becomes too vague; too many subwatersheds are considered; impact sources are often impossible to identify; too many stakeholders are involved and implementation responsibility is diminished; monitoring and implementation costs skyrocket; and non-urban sources confound protection efforts

- **Plan is a one-time study rather than a long-term and continuous management commitment –** plan does not fully commit resources and authority to a long-term process and after a period of time the report and recommendations are lost to competing priorities

- **Plan lacks local ownership and key stakeholder involvement in the watershed management process –** responsibility is handed off to consultants or technical staff; internal consensus and support are not generated and few stakeholders are involved in the process; consensus and support are not provided for elements which may be controversial

- **Budget for watershed plan is insufficient –** plan scope is too broad and ambitious for available funds; baseline mapping and monitoring often exhausts budget with little left for management process, stakeholder involvement, or implementation

- **Plan recommendations are too general --** recommendations often general as in: better erosion and sediment control (ESC), need for better agency coordination, wider use of stormwater treatment practices, or need for long term watershed monitoring, with no specifics on how to fund programs, what ordinances will require wider use of stormwater treatment practices or ESCs, where and how to construct specific stormwater treatment practices or stream rehabilitation projects, how to achieve better agency coordination, or how and when to conduct monitoring; management recommendations do not assign resources, responsibilities and timetables

The Watts Branch Watershed Plan was developed to avoid these pitfalls. The basic approach of rapid watershed planning is to make management decisions based on the amount of current and projected future impervious cover to achieve realistic and measurable goals. In particular, the broad goals of the Watts Branch Watershed Plan are that it be:

- **Scientifically credible** based on the best science that is available;

- **Democratic** in that a group of real citizens and watershed interest groups can help prepare

- them;

- **Effective** such that we are reasonably confident that we can achieve the water resource goals set for the watershed if the plan is fully implemented;

- **Locally-based** with a strong focus on the smaller subwatersheds that contain headwater streams;

- **Economically defensible** so that the needs for economic growth are balanced against the benefits of watershed protection;

- **Rapid**, since development can occur very rapidly, it is possible to dramatically change watershed quality in a few decades. Therefore, a brief planning phase should quickly lead to on the ground implementation of specific management tools with a 2-year time frame.

1.7 Stormwater Retrofitting and Stream Rehabilitation

Most urban watersheds such as Watts Branch are already impacted to some degree and often have little or no existing stormwater controls. In these types of watersheds, planning is generally focused on existing impacts, as opposed to being protection or conservation oriented. Managers are faced with the prospect of addressing problem areas. Common mitigation approaches are to implement stormwater retrofits and stream rehabilitation practices.

Retrofits are structural stormwater management measures for urban watersheds designed to help minimize accelerated channel erosion, reduce pollutant loads, promote conditions for improved aquatic habitat, and correct past mistakes. Simply put, these stormwater treatment practices are inserted in an urban landscape where little or no prior stormwater controls existed.

Stream rehabilitation practices can include riparian reforestation, wetland creation and enhancement, habitat creation, and streambank stabilization. For the Watts Branch study, the stream rehabilitation focus is primarily on opportunities for streambank stabilization using both “hard” or structural practices and bioengineering practices (practices that employ live vegetation).

Retrofits and stream rehabilitation practices come in many shapes and can address flood control, channel protection, and water quality treatment. Usually at least some kind of practice can be installed in almost any situation. But fiscal restraints, pollutant removal capability, and watershed capture area must all be carefully weighed in any retrofit selection criteria.

Stormwater retrofits and stream rehabilitation practices should be applied along with other available watershed rehabilitation tools for reducing pollutants and restoring habitat as part of a watershed rehabilitation program. Some of the many watershed rehabilitation strategies include:

- Improving aquatic habitat within urban streams
- Replacing or enhancing riparian cover along urban streams
- Promoting pollution prevention source controls within the watershed
- Recolonizing streams with native fish communities

Many, if not most, of these tools should be planned in conjunction with an urban retrofit and stream rehabilitation program, and rarely should be considered without one. Without establishing a stable, predictable hydrologic water regime which regulates the volume, duration, frequency, and rate of stormwater flow, many of these other tools may be disappointing failures. To successfully improve the overall aquatic health of an urban stream, stormwater retrofitting and stream rehabilitation are essential elements.

Retrofitting and stream rehabilitation can be daunting tasks, and usually expensive ones. The key to a successful program is to follow a systematic and straightforward process toward implementation. Retrofitting and stream rehabilitation is still more of an art than a science, and planners and designers who take an approach geared toward innovation will go a long way towards successfully planning, designing, and building stormwater retrofit and stream rehabilitation projects. Section 3 details the stormwater retrofit inventory that was conducted as part of the Watts Branch study, where 37 sites were identified as possible candidates for stormwater quantity and/or quality retrofits. The sites were prioritized using a ranking system (see Section 3), and detailed concept plans were prepared under Phase II of this project for the highest ranking sites. Section 4 details the stream rehabilitation inventory that was conducted. Thirty-five stream sites were identified as candidates for improvements. Priority sites were also selected for detailed concept plans under Phase II of the project.

1.8 Scope of Study

As previously mentioned, the Center's approach to developing a watershed management plan for Watts Branch employs the principles of a rapid approach, coupled with an emphasis on "stakeholder" involvement to produce a workable plan for implementation of specific management measures.

The planning process consisted of three phases of development: a watershed assessment stage, a conceptual design stage, and an implementation stage. In the assessment stage, the project team documented existing conditions within the watershed. Tasks included:

- A stream geomorphic assessment to assess the dynamic stream evolutionary process associated with altered urban hydrology
- A biological, physical and chemical stream survey to identify overall stream health and identify specific problem areas
- identification of potential stream rehabilitation and candidate stormwater retrofit opportunities within the basin
- A watershed planning charette to engage stakeholders in the watershed planning process, and
- Preparation of initial recommendations for employing management measures

In the second phase, the project team prepared conceptual designs, cost estimates and analyses of estimated benefits for specific management measures such as stormwater management retrofits, stream rehabilitation, wetland enhancement, and forest conservation.

In the third phase, the project team developed management recommendations for public outreach and education, bench mark and long term monitoring, and prioritization of implementation.

1.9 Watts Branch Partnership and Stakeholders

In a real sense, every current and future resident of a watershed is a stakeholder, even though they may be unaware of this fact. Watershed stewardship programs can increase awareness and broaden community support to implement watershed plans. The ideal group of stakeholders for designing a subwatershed plan are determined by the level of interest of local parties in water quality and resource protection issues. The list of non-agency and agency stakeholders in the Watts Branch Watershed Study are listed in Table 1.3.

Table 1.3 Stakeholders in the Watts Branch Watershed Management Process

Non-agency Stakeholders	Agency Stakeholders
Homeowners Association(s) Citizen Associations Watts Branch Partnership Developers (e.g., King and Thomas Farms) Watershed Property Owners Business Interests (industrial, commercial business owners) Gas, Oil and Utility Companies Montgomery College Lakewood Country Club	Rockville Parks and Recreations Departments Rockville Public Works Department State and Federal Regulatory Agencies MDE/WMA
Note: See section 2.5 for discussion on representative stakeholder involvement to date.	

The Watts Branch project approach was structured in a way to involve the public at various levels throughout the course of the project. The project approach placed an emphasis on getting input and involvement from the public early in the planning process. This allowed for contentious issues to be identified and addressed early in the planning phases and helped to identify what the important issues are to watershed residents. Establishing stakeholder pride and ownership in the plan leads to a greater chance of project success. The project scope has been developed to ensure that public involvement and participation remains a component of the watershed plan well after the immediate project.

The City's Watts Branch staff team formed the Watts Branch Partnership in September 1998 as a citizen-based advisory group to actively participate in the project. Homeowners and civic associations from the City's portion of the Watts Branch watershed were invited to send representatives. Ultimately, the majority of the associations within the study area participated over the course of the study. Members also included environmental group representatives and other interested residents. The Partnership members reviewed and commented on the scope of the study and consultant selection. The Partnership also attended several educational sessions to better understand urban stormwater management and stream protection, as well as the overall condition of the Watts Branch watershed. During the Phase I planning, the Partnership was heavily involved in the stormwater retrofit and stream stabilization project ranking and selection. In Phase II, the

Partnership reviewed each of the stormwater and stream concepts, and offered comments on elements important to residents, such as, appearance and landscaping, effects on recreation space, and trail connections. Many of the comments and concerns of the residents resulted in concepts that better fit the neighborhood goals. Specific components of the public involvement approach are described below.

A planning charette was held early (October 1999) in the planning process with interested stakeholders (see Section 2.5 for a summary of the charette), in which the preliminary findings of the stream assessment and retrofit and stream rehabilitation inventories were presented. The stakeholders participated in actual watershed exercises, such as setting realistic goals for the watershed plan, proposing alternative retrofit and stream rehabilitation sites, and making recommendations for a pollution prevention outreach and public education program.

City staff and the Center attended several civic association meetings or neighborhood meetings to explain the watershed study and local projects. The City used multiple forms of media to educate and inform the citizens about the project, including its cable TV station, a monthly City publication, signage posted in the neighborhoods, as well as direct mailouts. Much of the Phase I and II work culminated in two open houses held by the City which highlighted the project and provided detailed presentations of the priority stormwater retrofit and stream rehabilitation sites. City and Center staff were on hand to address and record comments and questions.

City and Center staff also discussed individual projects with appropriate state and federal agencies to review potential permit requirements and other environmental considerations. A number of stormwater management and stream stabilization projects will require permits for wetland or stream disturbance. These conceptual projects were presented to the Wetland Coordinating Committee, which includes representatives from Maryland Department of Environment, Maryland Department of Natural Resources and the Army Corps of Engineers, as well as Maryland-National Capital Park and Planning Commission and Montgomery County Department of Environmental Protection and Department of Permitting Services. Maryland's State Highway Administration was contacted regarding projects within the I-270 right-of-way. City staff also contacted and met with private land owners who had projects proposed on their property, such as Lakewood Country Club.

As a separate component of this project, a pollution prevention and public education program outline was prepared documenting and highlighting the behaviors most critical to modify and identifying specific strategies for modifying these behaviors. Media outreach techniques that have been identified as the most effective ways to influence these behaviors were identified. The guidance provided for developing a public outreach and education program will be instrumental to fostering a strong public involvement in the protection and upkeep of Watts Branch as well as other Rockville watersheds.

SECTION 2. CURRENT WATERSHED CONDITIONS

This section summarizes the results of several watershed assessments that have been conducted for this project. The assessments include channel enlargement, stream geomorphology, physical conditions, hydrologic, and public involvement. The discussion in this section has been limited to a presentation of findings and results. Technical theory and methodology discussions are provided in the appendices to this report.

2.1 Channel Evolution and Channel Enlargement

An important task of the Watts Branch project is to define the stream channel geomorphic characteristics. The assessment of the physical characteristics of the stream channel serves as an important foundation of the stream rehabilitation strategies and provides a reference on where the stream is in its evolutionary process. As stated in the introduction, streams characteristically enlarge as result of urbanization. This section provides a summary of the channel enlargement study results from the analysis of ten stations (study points) along the mainstem of Watts Branch (see Figure 2.1 for station locations).

2.1.1 The Concept of Channel Enlargement

The first evidence that stream channels enlarge in response to watershed development can be found in the high bank erosion rates measured for urban streams. Bank erosion accounted for an estimated two-thirds of the measured instream sediment load of an urban stream in California (Trimble, 1997). In contrast, most geomorphologists have found that bank erosion in rural streams comprises only 5% and 20% of the annual sediment budget (Walling and Woodward, 1995; Collins *et al.*, 1997). Research indicates that channel enlargement can begin at a relatively low level of watershed development, as indicated by the amount of impervious cover. One study estimated that channel erosion rates were three to six times higher in a moderately urbanized watershed (14% impervious cover) than in a comparable rural one, with less than 2% impervious cover (Neller, 1988).

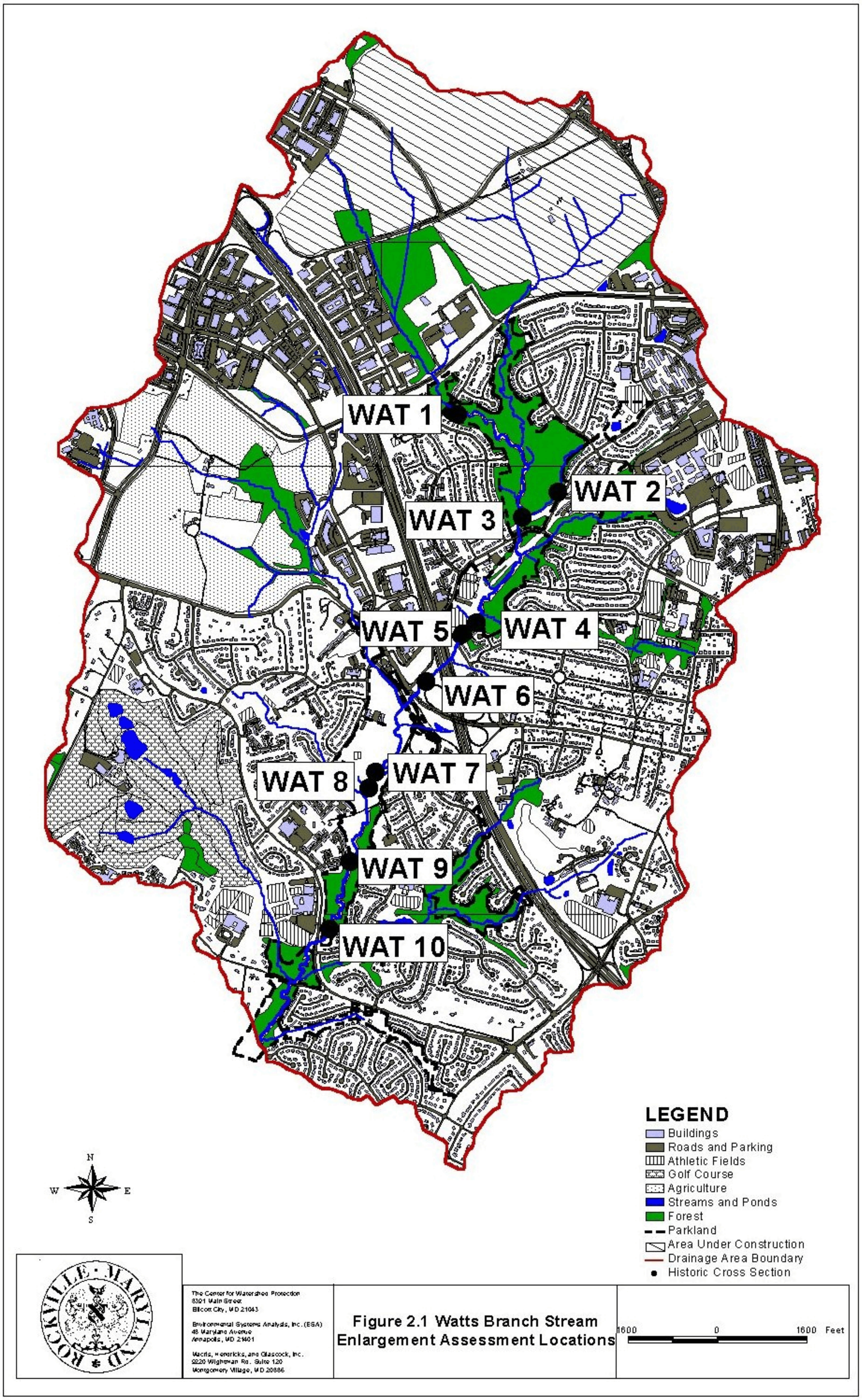
Further evidence that stream channels enlarge in response to watershed development lies in studies that have tracked the change in the cross-sectional area of stream channels over time. The simplest way to quantify these changes is to define an "enlargement ratio," which represents the ratio of a stream's current cross-sectional area to its pre-development cross-sectional area (or, in some cases, a cross-section from an adjacent undeveloped stream of equivalent watershed area) (Caraco, 2000).

The enlargement ratio takes the following form mathematically:

$$(\mathrm{Re})_{POST} = \left(\frac{(A_{BFL})_{POST}}{(A_{BFL})_{PRE}} \right)$$

where Re is defined as the channel enlargement ratio, 'A' represents the cross-sectional area of the stream channel, and the subscripts BFL, POST, and PRE refer to the bankfull stage, the post-disturbance condition, and pre-disturbance condition, respectively.

Figure 2.1 Watts Branch Stream Enlargement Assessment Location



It is worth noting that the bankfull stage does not necessarily mean the "top of bank," but rather refers to the water surface elevation associated with the dominant discharge for the particular channel. For unimpacted streams, this may in fact be the "top of bank," but generally for incised urban streams, this elevation tends to be somewhat less than the "top of bank."

The age of the development is also a critical variable in the amount of channel enlargement. In general, the longer a channel is exposed to the forces causing accelerated channel erosion, the larger the channel cross-sectional area, at least until such time as a channel has enlarged sufficiently to be in balance with the altered hydrologic forces caused by development. The effect of the age of development is represented by the concept of a "relaxation period." This is defined as the period of time required for a channel to reach an "quasi-equilibrium" state in concert with the level of watershed alteration, where the channel erosion processes are in a relative balance with the watershed forces causing erosion. The relaxation period for watersheds such as Watts Branch (i.e., alluvial streams) is estimated to be about 67 years (see Appendix A for a more detailed discussion).

The basic methodology to calculate channel enlargement relies on obtaining historical cross-sectional data from past surveys (often obtained from transportation agencies or public works departments that conducted surveys at the time of road construction or improvement projects) and comparing these with current cross-sectional data obtained from field surveys conducted at the time of the study. The approach also utilizes predictive (i.e., empirical) equations to estimate an ultimate channel enlargement ratio once the channel has enlarged sufficiently to be in balance with its hydrological forces. The reader is referred to Appendix A for a more detailed discussion on channel enlargement theory and assessment methodology.

To illustrate the concept of channel enlargement and how a channel responds over time to the effects of urbanization, it is useful to compare a channel cross-section over time. Figure 2.2 illustrates this change in channel morphology by comparing the cross-sectional area of a channel at three distinct points in time: historic, current, and ultimate. It is important to note that while the historic and current cross-sections are based on actual data, the ultimate cross-section is a hypothetical configuration based on a predicted increase in cross-sectional area.

Channel enlargement is also quite apparent in the field (Figure 2.3; same cross-section as shown in Figure 2.2). The exposed sanitary sewer manhole in the channel is due to a combination of plan form (i.e., lateral) adjustment of the channel as well as enlargement.

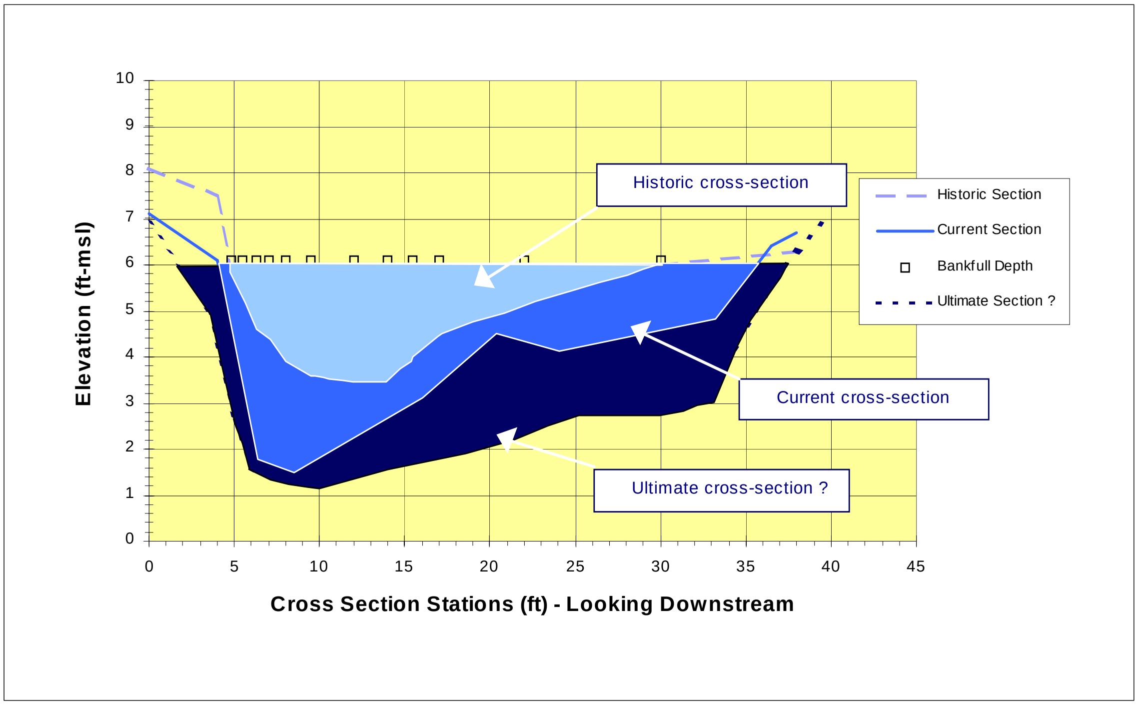


Figure 2.2 Watts Branch cross-section comparison (Note: cross-sections have been overlain for illustrative purposes only–actual sections do not share same datum.)

Figure 2.3 Photo looking downstream showing exposed manhole and enlarged channel

2.1.2 Results of Channel Enlargement Analysis

The primary objectives of the channel enlargement assessment were to:

Scenario 1. validate an empirical assessment technique to determine what the ultimate channel enlargement will be at each of the ten stations,
Scenario 2. determine where Watts Branch generally falls in the channel evolutionary process, and
Scenario 3. use the analysis to formulate stormwater rehabilitation strategies in the Watts Branch watershed.

The starting point for all of the enlargement analysis is to collect current conditions channel morphology and hydrologic data at each of the study points. A summary of these channel data at the ten cross-section locations, as determined from field surveys, is presented in Table 2.1.

Table 2.1 Summary of Channel Bankfull Data Under Current Conditions

Site	DA (acres)	I (%)	D_{BFL} (ft)	w_{BFL} (ft)	A_{BFL} (ft^2)	n_{BFL}	S (ft/ft)	Q_{BFL} (cfs)
WAT 1	364	34.5	2.1	15.3	24.6	0.033	0.010	143
WAT 2	151	50.2	1.5	18.3	22.9	0.034	0.011	116
WAT 3	832	26.6	2.15	22.9	35.8	0.026	0.005	186
WAT 4	1540	28.6	3.0	36.2	86.5	0.036	0.009	587
WAT 5	1540	28.6	2.6	32.9	61.8	0.031	0.013	496
WAT 6	1653	30.1	3.1	30.4	68.5	0.034	0.010	493
WAT 7	2443	31.3	4.0	27.0	70.3	0.034	0.008	481
WAT 8	2479	31.1	3.6	21.0	61.2	0.034	0.008	438
WAT 9	2829	30.3	3.5	31.3	98.9	0.035	0.007	694
WAT 10	2860	30.1	4.2	36.5	119.3	0.031	0.004	750

DA = Drainage area; I = Basin Imperviousness; D_{BFL} = Bankfull channel depth; W_{BFL} = Bankfull channel width; A_{BFL} = Bankfull channel cross-sectional area; n_{BFL} = Manning roughness coefficient at bankfull depth; S = Channel longitudinal slope; Q_{BFL} = Channel bankfull flow rate

The current bankfull cross-sectional areas and flows are, in turn, used to estimate historic cross-sectional area and to forecast the ultimate cross-sectional area.

Once the empirical approach is determined to be valid based on the observed Watts Branch data, it is then possible to apply the channel enlargement regression equation to estimate the ultimate channel enlargement conditions based on future build-out predictions (this primarily involves the additional development of the King and Thomas Farm parcels within the Watts Branch watershed). The estimated ultimate enlargement results are then used as one of a suite of indicators for development of stream rehabilitation and stormwater retrofit strategies.

Table 2.2 presents the results of the analysis, including the estimated impervious cover for each of the drainages tributary to the ten stations under projected full build-out conditions. The regression equation for the channel enlargement yields the build-out ultimate channel enlargement ratio. The estimated ultimate channel cross-sectional area is determined by multiplying the ultimate enlargement ratio by the pre-disturbance cross-sectional area.

Table 2.2 Ultimate Channel Enlargement Ratios and Cross-Sectional Area Assuming Full Watershed Build-out

Site	Est. Build-out I[1] (%)	Current $(Re)_i$	Build-out $(Re)_{ULT}$	Current A_{BFL} ft^2	Build-out ft^2
WAT 1	60	2.1	6.65	24.6	77.1
WAT 2	50	1.9	5.09	22.9	60.6
WAT 3	54	2.0	5.62	35.8	102.4
WAT 4	43	2.0	4.14	86.5	176.4
WAT 5	43	1.7	4.14	61.8	153.7
WAT 6	44	1.8	4.21	68.5	158.6
WAT 7	45	2.1	4.45	70.3	150.1
WAT 8	45	1.1	4.40	61.2	243.8
WAT 9	43	1.2	4.06	98.9	323.8
WAT 10	42	1.4	4.03	119.3	341.6

[1] Impervious cover estimates based on assumed build-out of King and Thomas Farms at 52 and 48 percent impervious, respectively

$(Re)_i$ = current enlargement ratio; $(Re)_{ULT}$ = ultimate enlargement ratio; A_{BFL} = bankfull cross-sectional area

2.1.3 Management Implications

The channel enlargement analysis documents some findings about how Watts Branch has changed over time. First, based on the area weighted average age of disturbance (i.e., the approximate time that has elapsed since development began) for each of the ten study points, the observed channel locations are only about 30 to 40 percent of the way along their evolutionary process[1]. The total time for the enlargement process to occur in alluvial streams such as Watts Branch is estimated to be 67 years (MacRae, 1999) from the onset of significant land use changes within the watershed. Therefore, we can expect to see another 40 to 50 years of channel reaction and adjustment to development influences before a state of quasi-equilibrium is reached.

Second, the existing channel cross-sectional area is expected to increase between two and four times, depending on the study point (Table 2.2). For example, the current bankfull cross-sectional area at WAT 1 of 24.6 square feet is projected to ultimately enlarge (at full build-out) to a bankfull cross-sectional area of 77.1 square feet, or about a three fold increase. The significant changes in channel enlargement have occurred, in some cases, where stormwater control practices exist upstream. This suggests that the method of control employed in the past has been ineffective at protecting the channels from erosive stormwater flows.

[1] Geomorphic changes and responses do not occur immediately upon a change in the land use in a watershed. The channel alteration, adjustment, and transition processes occur over several years, depending on the basic geomorphic stream type. For alluvial streams like Watts Branch, this process can take as long as 70 years.

The two findings above are important to the overall strategy that is taken from a stream rehabilitation and stormwater retrofit standpoint. Specifically, since the study points all indicate that the stream channel still has a long way to go before reaching a state of relative equilibrium, the in-stream rehabilitation techniques implemented should be able to withstand future adjustments in channel downcutting, widening, and plan form. Stream rehabilitation techniques such as live stakes and coconut rolls are examples of practices that provide flexibility that allow for some channel movement[2]. In addition, because there is a large increase in channel cross-sectional area predicted, a focus of the stormwater retrofitting sites will be to provide channel protection storage (i.e., 24-hour extended detention of the 1-year return frequency storm) to help mitigate the erosive forces associated with the stormwater runoff.

It will also be necessary to coordinate and optimize the stream rehabilitation and stormwater retrofit strategies outlined above. In other words, in-stream rehabilitation measures will be that much more effective if they can be combined with retrofit controls immediately upstream that will help control the volumes, rates and flow frequency of erosive conditions.

It is important to note that the ultimate build-out analysis does not account for the effectiveness of more advanced stormwater management techniques that have been or will be implemented with the development of the King Farm and Fallsgrove parcels. With some of the more stringent controls in place (e.g., channel protection design criteria requiring 24-hour extended detention of the 1-year return frequency storm), it is hoped that the projected channel enlargement will be less significant. The efficacy of these criteria is still largely theoretical, and it will require monitoring and data collection to adequately assess them.

2.2 Stream Channel Conditions

Two in-stream assessments techniques were performed to evaluate overall stream channel conditions. The assessments included a rapid geomorphic assessment (RGA) and a rapid stream assessment technique (RSAT). The RGA was performed to evaluate channel stability at each of the ten field survey sites in the Watts Branch watershed. As previously described in Section 2.1, the ten locations were chosen based on the representativeness of each reach and correspond to where historic cross-sectional information existed. In addition, the RGA serves as the data collection tool from which much of the channel enlargement analysis is generated. The RSAT was implemented to determine the physical attributes of all perennial reaches of Watts Branch. Observations were recorded at approximately 400-foot intervals and wherever unique conditions or potential problems were apparent. Evaluation categories include channel stability, channel scouring and deposition, physical in-stream habitat, water quality, riparian habitat condition, aesthetics and remoteness. Findings of the RSAT assist in identifying candidate sites for stream rehabilitation, reforestation, and wetland improvement. A more detailed description of the methodologies and findings of these two assessments is provided below.

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[2] There are some stream rehabilitation sites that will require a more rigid design to protect utilities, infrastructure, or property concerns.

2.2.1 Rapid Geomorphic Assessment

The Rapid Geomorphic Assessment process uses a number of visually observed factors to provide a semi-quantitative assessment of a stream's current stability (CWP& MacRae, 1999). A length of approximately ten times bankfull channel width is investigated at each site to determine geomorphic and channel metrics. The primary purpose of the RGA is to corroborate the findings of the more quantitative channel enlargement assessment and to help define past or current modes of channel adjustment (i.e., aggradation, degradation, widening and/or plan form adjustment). The RGA notes whether change in channel form has occurred or is still occurring, however, it does not provide a measure of the rate of change.

The process consists of identifying the presence of in-stream channel features resulting from a variety of geomorphic processes. The protocol is comprised of four factors: Aggradation (AI), Degradation (DI), Channel Widening (WI), and Planimetric Form Adjustment (PI). Each Factor consists of seven to 11 indices, which are measures of the morphological state of the channel. For example, presence of leaning trees, fence posts, etc., to which the observer is required to provide a “yes” response if present or “no” response if absent. The total number of “yes” responses is totaled for each Factor and divided by the total number of “yes” and “no” responses to derive a Score for each Factor. These Scores are then summed and divided by four to arrive at the Stability Index (SI), as presented in the following equation:

$$SI = \frac{AI + DI + WI + PI}{m}$$

in which ‘m’ is the number of factors (four for alluvial streams like Watts Branch).

The stability index (SI) provides an indication of the stability of the creek channel at a given time. The observed geomorphic features may be current or historic. Consequently, other corroborative levels of investigation (e.g., enlargement analysis) are necessary to determine whether evidence of instability is associated with current processes and what the magnitude of the activity rates may be. Previous experience with the RGA protocol indicates that the Score values may be interpreted as follows:

Stable ($SI \leq 0.2$):	Channel metrics are within the expected range of variance (one standard deviation from the mean)
Transitional ($0.2 < SI \leq 0.4$):	Channel metrics are within the expected range of variance for a stable condition but channel shows signs of stress; and,
In Adjustment ($SI > 0.4$):	Channel is outside of the expected range of variance and evolving toward a new equilibrium position.

A summary of the Stability Index values and classification is presented in Table 2.3, and the RGA field survey forms for each station are presented in Appendix B.

Table 2.3 Summary of Channel Stability Assessment Using the Rapid Geomorphic Assessment Form

Basin	Site ID	RGA Factor				Stability Index	Stability Class
		AI	DI	WI	PI	(SI)	
Watts Branch	WAT 1	0.29	0.40	0.63	0.14	0.37	Transitional
Watts Branch	WAT 2	0.43	0.38	0.56	0.43	0.45	In Adjustment
Watts Branch	WAT 3	0.71	0.17	0.50	0.29	0.43	In Adjustment
Watts Branch	WAT 4	0.29	0.38	0.75	0.43	0.47	In Adjustment
Watts Branch	WAT 5	0.86	0.25	0.63	0.29	0.50	In Adjustment
Watts Branch	WAT 6	0.29	0.33	0.83	0.86	0.59	In Adjustment
Watts Branch	WAT 7	0.29	0.43	0.75	0.57	0.52	In Adjustment
Watts Branch	WAT 8	0.57	0.40	0.50	0.43	0.48	In Adjustment
Watts Branch	WAT 9	0.57	0.10	0.44	0.14	0.30	Transitional
Watts Branch	WAT 10	0.17	0.14	0.56	0.00	0.24	Transitional

Notes
SI = Modified Stability Index for Watts Branch Conditions; AI = Aggradation Factor; DI = Degradation Factor; WI = Widening Factor; PI = Planimetric Adjustment Factor

The RGA also includes the collection and recording of several other factors such as bed material characteristics to determine roughness coefficients and channel bank soil consistency to help assess historic degradation and aggradation patterns. These data are also used in the bankfull flow calculations and are important in the development and verification of the channel enlargement analysis. The following discussion describes each of these elements.

Bed Material Assessment

Pebble counts were used to characterize the bed material. Samples were collected near the location of the primary cross-section along a transect perpendicular to the banks running from left bank toe to right bank toe. The pebble counts consisted of measuring the lengths of the three major axes; length (l), width (w), and height (h), of individual pebbles obtained through random grab samples along the transect. A minimum of 50 pebbles were collected at each station to obtain the above metrics. Data collection included all particles regardless of size including large anomalous boulders. The data were then used to calculate a pebble size distribution or mass curve. In determination of the mass curves, however, the largest particle, if more then 15% larger than the second largest particle, was removed from the analysis.

The data were used to help classify the channel in the RGA analysis as well as determining roughness coefficients (Manning's n values) for the bed material, which were in turn used to develop the current estimates for bankfull flows and cross-sectional areas.

Bank Soil Survey

Bank materials were analyzed during the field study using standard soil consistency tests: stickiness (X1), plasticity (X2), and firmness (X3) (see Diagnostic Geomorphic Field Survey Form, Appendix B). These metrics were determined for each definable soil horizon or stratigraphic unit on both left and right banks. The three metrics were then summed to determine a value that was subsequently correlated with shear stress for use in classifying the channel in the RGA analysis. The soil survey data were also used for the determination of bank roughness coefficients.

Field Sketches

Sketches of the channel in plan form were made 50 feet upstream and downstream of the cross-section location as well as sketches of the left bank and right bank profiles as part of the field notes for each site. Features in the plan form sketches consisted of riffle and pool location, point bars, lobate bars, sloughing banks, large organic debris, and other significant channel characteristics. Features in the bank profiles included in these sketches consisted of soil horizons, bank vegetation, major terraces and approximate elevations of such features.

2.2.2 Rapid Stream Assessment Technique (RSAT)

Environmental Systems Analysis, Inc. (ESA), in cooperation with the Center for Watershed Protection and the City of Rockville Department of Public Works, evaluated and characterized the physical characteristics of approximately 12.5 miles of perennial streams (streams which flow year round) within the City of Rockville which are part of the Watts Branch watershed. This assessment was performed using a field method known as the Rapid Stream Assessment Technique (RSAT) (Galli, 1996). This technique was modified to ensure compatibility with project objectives and resources for the study area. The modified RSAT was used to evaluate more than 30 physical stream conditions at stations located at 400-foot intervals (between 12 and 13 observation points per mile), or wherever unique conditions or potential problems were apparent. Evaluation categories included channel stability, channel scouring and deposition, physical in-stream habitat, water quality, riparian habitat condition, aesthetics and remoteness.

Figure 2.4 identifies the stream reaches that were assessed using RSAT. As described in Section 1.3, the numbering convention used to identify reaches is based on the order of the stream (e.g., first order through fourth order). For example, there is one fourth order reach (i.e., 401), two third order reaches (i.e., 301 and 302), six second order reaches and so on. Stream reaches were numbered in a clockwise direction starting with first order streams at the most downstream point. Under this convention, the southern most first order tributary found on the Lakewood Country Club property was numbered 101.

All of the perennial streams in the Watts Branch watershed within the City were physically surveyed. Severe drought conditions were present throughout Maryland in 1999, and as a result, low baseflow or sub-baseflow conditions were observed in all streams. A total of 165 stations were visited, with 132 stations actually being investigated using modified RSAT data collection protocols (see Figure 2.5). The remaining thirty-three stations were not conducive for RSAT evaluation because they lacked either a riffle (extensive run or pool) or were found to be ephemeral or intermittent, concrete lined, or piped (closed section). Photographs of each station were previously provided to the City and are on file at the Department of Public Works as part of the project record (see Appendix F for a list of additional information on file with the City). Original data sheets for each observation point are included in the full report which is in Appendix C.

ESA modified the RSAT to ensure compatibility with project objectives and stream resources contained within the study area after approved by the City of Rockville. A major component of this study is the RSAT scoring system which provides a numeric score for each station based on the following seven evaluation criteria:

- Channel stability: Assessment of bank stability / degree of erosion.
- Channel scouring / sediment deposition: Assessment of stream scour and sediment load based primarily on the amount of embedded substrate.
- Physical in-stream habitat: An assessment of in-stream habitat based on wetted perimeter, pool depth and cover, substrate composition and overall diversity.
- Water quality: An indirect assessment of water quality based on water clarity and substrate fouling.
- Riparian habitat conditions: Evaluation of riparian habitat based on canopy closure, buffer width, and presence of wetlands.
- Aesthetic rating: An evaluation of the amount of disturbance (refuse, invasive plants, etc.) to the stream and riparian community.
- Remoteness: The degree to which the station is removed from access points such as trails and roads.

Scores were assigned for each of these categories, the sum of which provides the numeric score for the station (see Table 2.4 for a breakdown of the criteria scoring). A ranking of “Excellent”, “Good”, “Fair”, and “Poor” was then assigned to each station based on the following score ranges:

Score	***Ranking***
42-56	Excellent Condition
26-41	Good Condition
16-25	Fair Condition
< 16	Poor Condition

Figure 2.4 Watts Branch Stream Nomenclature

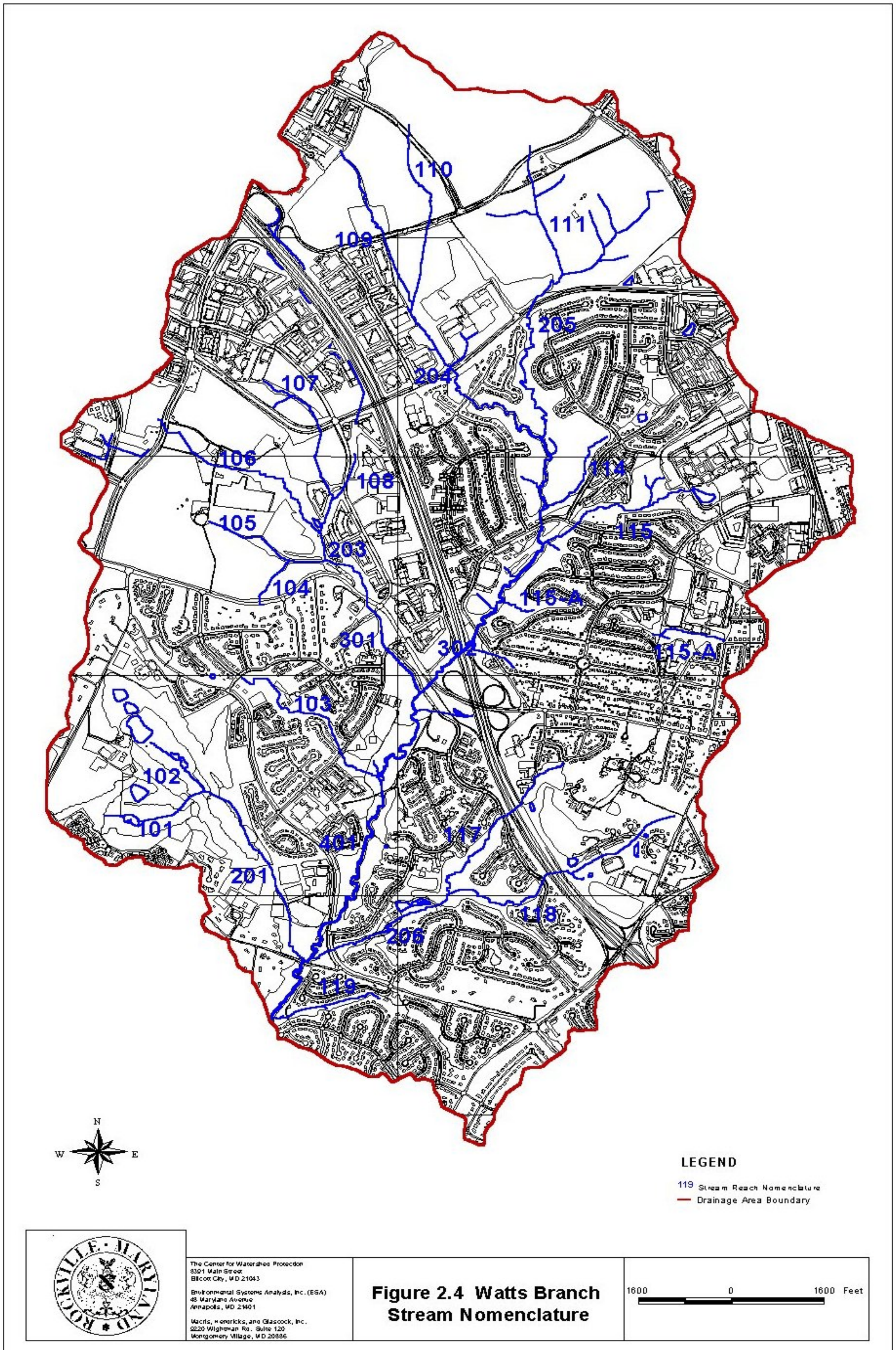
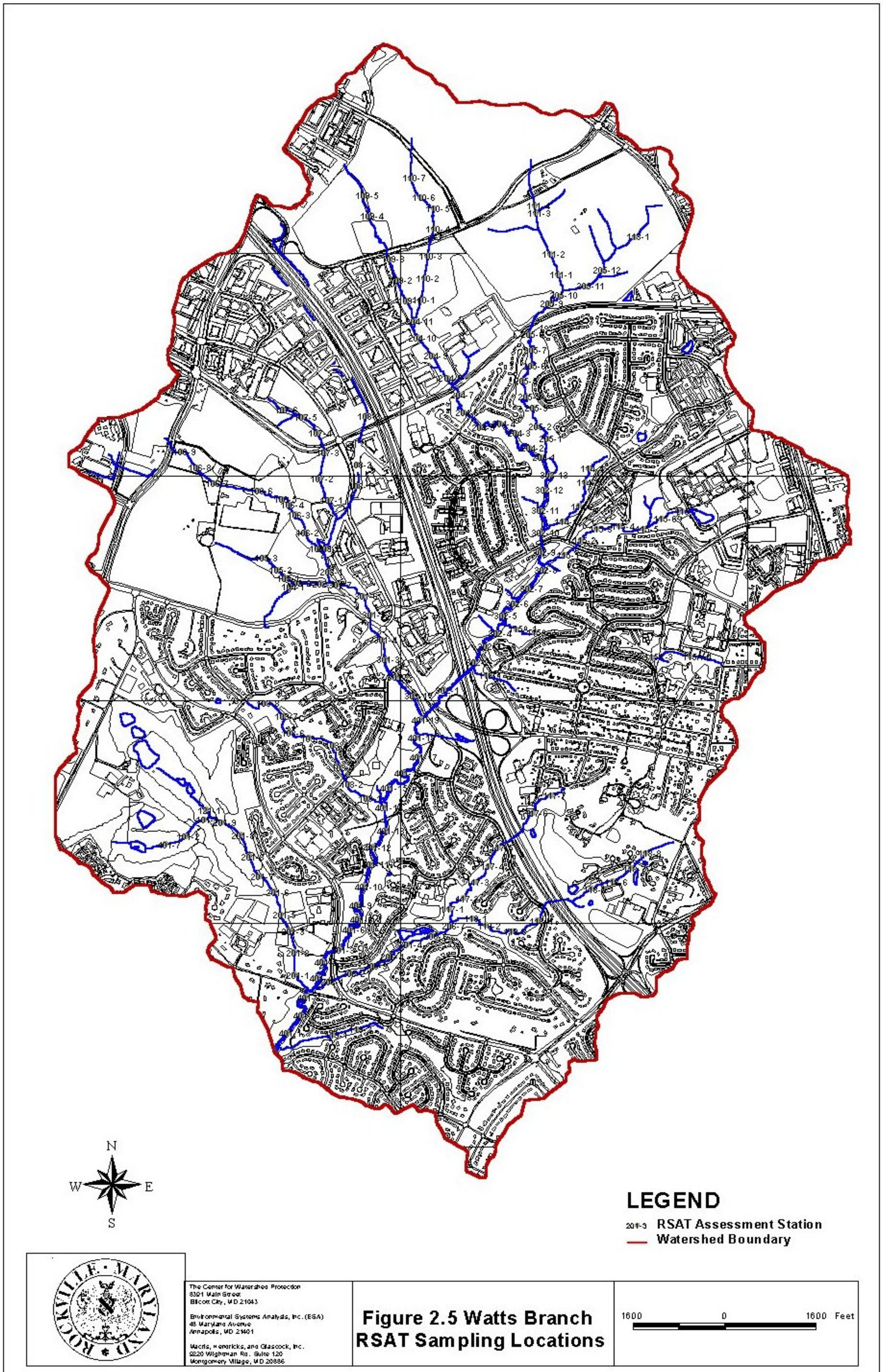


Figure 2.5 RSAT Sampling Locations



Evaluation Category	Excellent	Good	Fair	Poor
1. Channel Stability	• >80% stable banks • Outside banks <2' high, very stable • Exposed roots lacking • Channel, highly resistant **9-11**	• 71-80% stable banks • Outside banks 2-3' high, stable • Exposed roots old, large • Channel, resistant **6-8**	• 50-70% stable banks • Outside banks 3-4' high, unstable • Exposed roots young, common • Channel, erodible **3-5**	• <50% stable banks • Outside banks >4', highly unstable • Exposed roots young, abundant • Channel, highly erodible **0-2**
2. Channel Scouring/Sediment Deposition	• <25% embedded silts sands • High number of deep pools • Sand deposits rare, absent • Point bars fully incorporated • Water clear • Riffles bends frequent **7-8**	• 25-50% embedded silts sands • Moderate number of deep pools • Sand deposits uncommon • Point bars stable, vegetated • Water slightly turbid • Riffles bends common **5-6**	• 50-75% embedded silts sands • Low-moderate number of deep pools • Sand deposits common • Point bars large, unstable • Water generally turbid • Riffles bends not common **3-4**	• >75% embedded silts sands • Few, if any deep pools • Sand deposits predominate • Point bars unstable with fresh sand • Water opaque • Riffles bends, general lack of **0-2**
3. Physical In-Stream Habitat	• Wetted perimeter >85% • Riffle run pool, diverse habitat • Pools >24" dense cover structure • Riffle substrate >50% cobble gravel **7-8**	• Wetted perimeter 61-85%. • Riffle run pool, relatively diverse • Pools 18-24" some cover structure • Substrate 30-50% cobble gravel **5-6**	• Wetted perimeter 40-60% • Riffle run pool, few pools • Pools 12-18" little cover structure • Substrate 10-30% cobble gravel **3-4**	• Wetted perimeter <40% • Riffle run pool, poor habitat • Pools <12" no cover structure • Riffle substrate <10% cobble gravel **0-2**
4. Water Quality	• Clarity, visibility 3 ft. > • No odor • Substrate fouling 0-10% **7-8**	• Clarity, visibility 1.5 - 3.0' • Slight organic odor • Substrate fouling 11-20% **5-6**	• Clarity, visibility 0.5 - 1.5' • Moderate on-going odor • Substrate fouling 21-50% **3-4**	• Clarity, visibility <0.5' • Strong organic odor • Substrate fouling >50% **0-2**
5. Riparian Habitat Conditions	• Forested buffer >200' • Canopy closure >80% • Bank vegetation 90% • Adjacent wetlands, 100-200' **6-7**	• Forested buffer 100-200' • Canopy closure 60-79% • Bank vegetation 70-90% • Adjacent wetlands, 200-500' **4-5**	• Riparian buffer 50-100' • Canopy closure 50-60% • Bank vegetation 50-70% • Adjacent wetlands, 500'> **2-3**	• Riparian buffer <50' • Canopy closure <50% • Bank vegetation <50% • Adjacent wetlands, rare to none **0-1**
6. Aesthetic Rating	• Human refuse, little to none • Vegetative matrix natural state **6-7**	• Human refuse, minor • Vegetative matrix minor disturbance **4-5**	• Human refuse, moderate • Vegetative matrix moderate disturbance **2-3**	• Human refuse, extensive • Vegetative matrix vegetation lacking **0-1**
7. Remoteness	• Access 500'> **6-7**	• Access 500'< **4-5**	• Access Roadside or Trail **2-3**	• Access In Backyards **0-1**

Table 2.4 ESA Modified RSAT Evaluation Method (Based after Galli, 1996)

It is of note that this RSAT system does not correspond with the total numeric scores for all of the seven evaluation categories (i.e., the sum of ranges listed for the individual evaluation categories for "excellent" would be 48-56). This subjective ranking system was developed as a result of numerous field trials and modified based on the best professional judgement of biologists and planners who have expertise in the field of stream ecology. The result is a ranking system which has been scaled to effectively characterize and differentiate stream reaches, including those which have been impacted and/or urbanized. Although the rankings are subjectively based, the scores are absolute, and therefore reaches with a higher score are in better overall condition than reaches with lower scores, regardless of the category. Thus, when reviewing the data, emphasis should be placed on the numeric score of the station or reach rather than the descriptive category in which the score falls.

2.2.2.1 RSAT Results

Of the 132 RSAT stations sampled during this study, only four stations ranked "excellent", and only two ranked "poor". The remaining 126 stations were found to be either "good" or "fair". The highest single score (45) was found at a station on a first order stream located on the Thomas Farm (Fallsgrove), and the lowest (10) occurred at a station on a first order stream immediately downstream of I-270 which flows through the Fallsmead community. When individual scores were averaged within stream reaches, all of the reaches rated either "fair" or "good" (see Figure 2.6 and Table 2.5).

The stream reach with the highest average score (33.1) is a first order tributary located on the Lakewood Country Club; the stream with the lowest average score (21.8) is a second order tributary which flows through the community of Fallsmead in the southern portion of the study area. It is worth noting that the entire main stem of Watts Branch within the study area had average scores in the "good" range.

As outlined in Table 2.4, streams with "good" scores generally have more stable banks, a cleaner substrate, a diversity of habitat types including deep pools, good water quality, forested buffers, and typically exist in a relatively natural setting. The RSAT scores are weighted in favor of channel stability, sediment deposition, in-stream habitat, and water quality. However, because the scoring is cumulative, streams with an overall "good" score can have deficiencies in one or more of the seven evaluation categories. Therefore, a "good" score does not necessarily preclude the need for rehabilitation, stabilization, and/or other management activities. The converse is also true. Streams rated "fair" may exhibit "excellent" or "good" characteristics in one or more of the evaluation categories. For this reason, individual scores for a given station should be consulted to gain an understanding of the overall condition of the stream reach.

Figure 2.6 RSAT Stream Reach Condition Rating Results

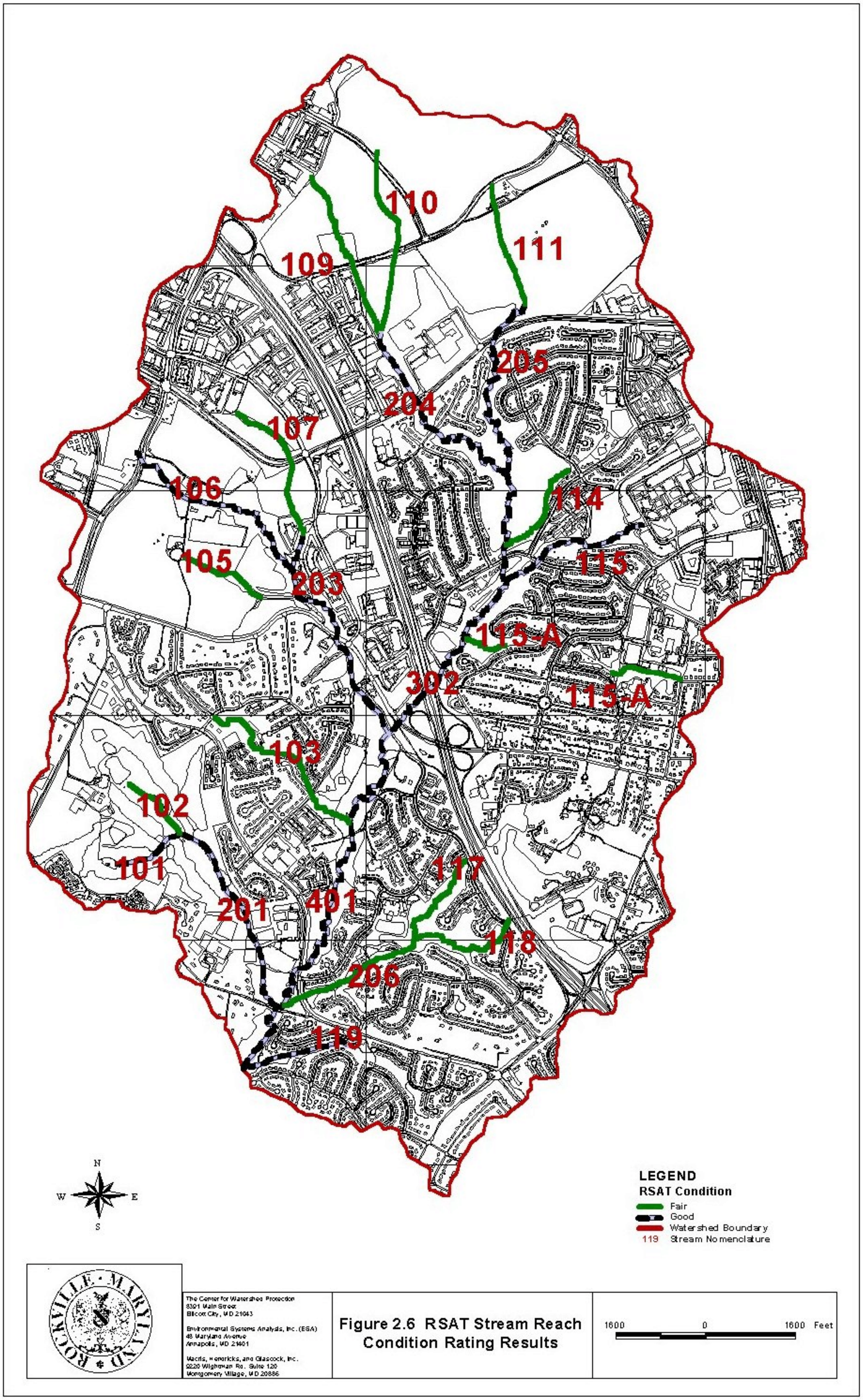


Table 2.5 Summary of Watts Branch RSAT Scores by Segment

Stream Segment	# RSAT Data Points / # of Points Investigated	Channel Stability (avg.) (0-11)	Scouring & Deposition (avg.) (0-8)	Physical In-Stream Habitat (avg.) (0-8)	Water Quality (avg.) (0-8)	Riparian Habitat Condition (avg.) (0-7)	Aesthetic Rating (avg.) (0-7)	Remoteness (avg.) (0-7)	Average Score for Reach (Sum of avg.'s)	Ranking of Stream Segment
101	3/3	9.7	6.0	5.7	4.0	2.0	4.7	1.0	33.1	Good
102	1/1	5.0	6.0	5.0	4.0	1.0	2.0	1.0	24.0	Fair
103	9/9	4.4	4.1	4.3	5.5	2.1	2.4	1.4	24.2	Fair
104	0/1	ND	ND	ND	ND	ND	ND	ND	ND	Non-Rsat
105	3/3	5.0	2.0	2.3	4.3	3.3	3.0	3.7	23.6	Fair
106	5/9	6.8	4.8	5.4	4.4	4.6	4.6	3.8	34.4	Good
107	6/6	3.3	4.0	3.5	5.0	2.0	2.0	3.3	23.1	Fair
108	0/3	ND	ND	ND	ND	ND	ND	ND	ND	Non-Rsat
109	4/6	4.8	3.3	2.5	2.8	3.8	2.5	2.5	22.0	Fair
110	7/7	5.3	3.1	2.4	5.0	3.4	2.3	1.4	22.9	Fair
111	4/4	6.0	4.3	3.5	5.0	2.5	2.5	1.0	24.8	Fair
114	0/4	ND	ND	ND	ND	ND	ND	ND	ND	Non-Rsat
115	7/7	4.0	4.1	3.3	4.6	3.9	3.6	2.7	26.2	Good
115A	3/4	3.7	2.7	2.7	5.0	3.3	3.0	1.7	22.1	Fair
117	5/7	3.4	3.0	2.4	5.0	4.6	3.4	3.2	25.0	Fair
118	4/8	4.0	3.0	3.3	3.8	3.8	3.3	2.8	23.8	Fair
119	2/2	9.0	4.5	4.0	3.5	4.0	4.0	1.0	30.0	Good
201	8/9	5.0	5.1	4.5	4.5	2.3	2.6	2.3	26.3	Good
202	0/2	ND	ND	ND	ND	ND	ND	ND	ND	Non-Rsat
203	2/3	8.0	5.0	4.0	4.5	2.0	2.5	1.0	27.0	Good
204	10/11	6.4	5.1	4.1	4.8	4.6	3.7	3.3	32.0	Good
205	9/12	5.3	3.9	4.3	4.3	4.3	3.7	2.4	28.2	Good
206	7/7	3.6	3.4	3.1	5.0	2.7	2.4	1.6	21.8	Fair
301	6/7	5.3	4.7	4.7	4.0	2.8	3.5	2.5	27.5	Good
302	12/13	5.8	4.7	4.4	4.8	4.4	4.3	4.1	32.5	Good
401	18/19	4.6	3.5	4.3	4.4	3.8	3.2	2.2	26.0	Good

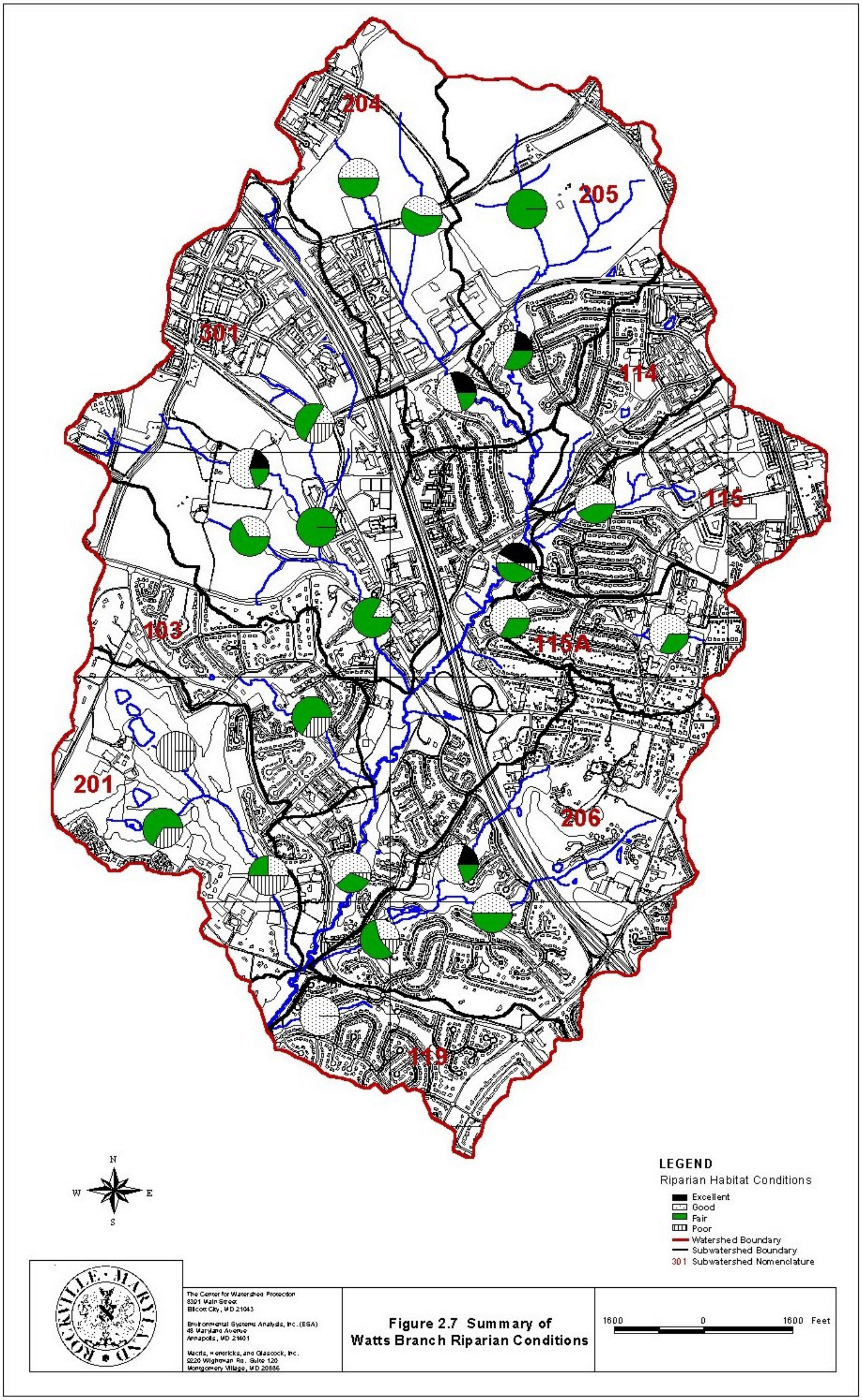
ND = No Data. Station not investigated because it lacked either a riffle or were found to be ephemeral or intermittent, concrete lined, or piped.

This point is evident when the riparian habitat conditions criteria are analyzed (Figure 2.7). For example, reach 101 (the Lakewood Country Club reach which had the highest overall average score) had a riparian habitat score that was fair (about 65%) or poor (about 35%). The low riparian scores were largely due to a lack of dense forest cover along the reach. Consequently, looking at the results of individual RSAT criteria is useful from a management strategy standpoint. For example, reforestation and riparian enhancement is often a cost-effective watershed rehabilitation tool. Figure 2.7 can be used as a diagnostic tool to identify reaches that are in most need of riparian reforestation and enhancement.

One of the primary purposes of the RSAT assessment is to identify candidate sites for stream rehabilitation and to provide context for specific design concepts, such as stream channel stabilization or habitat creation. For example, areas of significant erosion that are present within the RSAT channels were identified and targeted for rehabilitation by scoring these sites low on the channel stability index[3]. Concepts to address erosion and bank stabilization are recorded on individual data sheets at each station (see Appendix C). In addition, site conditions such as existing deficiencies or problems in stream and riparian areas, safety and property hazards, and wetland creation or enhancement opportunities are noted in the field. A more detailed presentation of the stream rehabilitation inventory is presented in Section 4.

[3] While field observations and RSAT scoring identified reaches of erosion and instability that showed potential for stream rehabilitation, the ranking system described in Section 4 ultimately narrowed the list of candidate stream rehabilitation sites.

Figure 2.7 Summary of Watts Branch Riparian Conditions



2.2.3 Conclusions From Stream Channel Conditions Assessment

Based on the findings from the channel enlargement assessment, RGA and RSAT, some general observations can be made with regard to the best and worst stream reaches within Watts Branch can be made (in terms of stability and physical habitat). Key findings include:

- Station 1 (see Figure 2.1 for station locations) is beginning to show signs of stress and is close to being in an "adjustment" period (i.e, evolving towards a new equilibrium in response to altered hydrology). The RSAT scores in the vicinity of Station 1 are good. This suggests that since the channel is trending towards an adjustment period where it is striving to achieve a new equilibrium, the overall physical health of the stream might be expected to decline, particularly in the absence of management measures.

- Station 2 was a "non-RSAT" reach due to the lack of flow. This station is representative of a highly impacted reach of stream and is perhaps the worst portion of the entire watershed. Much of this can be attributed to the fact that this subwatershed has the highest impervious cover of the ten subwatersheds (50%), and much of the historic channel has been piped through the subwatershed. The highly urban nature and pipe infrastructure cause hydrologic responses to be "flashy" with little groundwater recharge and return flows to supplement dry weather baseflow periods. The biological community is greatly impacted as a consequence.

- Station 3 is somewhat anomalous in that it is "in adjustment," yet scored excellent on the RSAT. The station shows indications of aggradation, which is the primary reason for the stability index being in the "in adjustment" range. The source of the aggradation is likely due, in part, to the relatively flat slope in this reach and the downstream grade control (i.e., Nelson Street culvert). Despite the aggradation, the channel appeared to be more stable than some of the stations that were experiencing active downcutting. This was also reflected in the RSAT score.

  Further complicating the conditions at this site is the fact that it has a large enlargement ratio (5.62), which suggests that the channel is expected to ultimately widen and/or downcut substantially. The enlargement ratio may be over-stated, however, due to the fact that the current channel cross-section location was a few hundred feet upstream of the historic channel cross-section location. This shift in locations was due to a gas line crossing which is associated with a channelization of the stream (i.e., concrete-lined channel) just upstream of the Nelson Street culvert crossing. Either the gas line crossing or the culvert may have contributed to the small historic cross-sectional area. Similarly, it was necessary to locate the RSAT station upstream of the gas right-of-way to avoid the influence of the channelization.

- Stations 4 through 8 are all "in adjustment," where they are evolving towards a new equilibrium. The RSAT scores from these stations were either "good" or "fair," with Stations 4 and 5 (Woodley Gardens Park) exhibiting the most impacted reaches.

- Stations 9 and 10, the most downstream stations, are in "transition." It is possible that this reach of the stream has evolved the most of all the reaches and is actually moving from the "transition" stage into the "stable" stage. The RSAT scores for these reaches were "fair" which

- supports the above observation. In other words, the channel has reached a maximum point in the adjustment process and as a consequence, the physical habitat has been impacted.

2.3 Hydrologic Modeling

An updated TR-20 hydrologic analysis of the Rockville portion of the Watts Branch watershed was undertaken as part of this study. The analysis was undertaken to provide additional runoff information to use in assessing the geomorphologic status of streams, to assess the effect of existing and proposed stormwater facilities, to use for concept stormwater control facility designs and to update a hydrologic study previously prepared for the City (ETA, 1989). TR-20 is a widely applied hydrologic model developed by the Natural Resource Conservation Service's (NRCS). The program is a physically based event model which computes direct runoff resulting from any synthetic or natural rainstorm. Runoff hydrographs are generated and routed through channels and reservoirs. Peak discharges, the time of their occurrence, water surface elevations and duration of flows can be computed at specified cross-sections or structures.

2.3.1 Background

Engineering Technologies Associates (ETA), Inc. prepared a hydrologic study for the City of Rockville in April 1989 that included a hydrologic analysis using TR-20, a hydraulic analysis using the United States Army Corps of Engineers HEC-2 Water Surface Profile computer program, an analysis of existing and proposed stormwater management facilities and a feasibility study of proposed stormwater facilities.

The ETA hydrologic study evaluated a series of watershed development scenarios including: Predevelopment, Existing Development with Existing and Authorized Facilities and Ultimate Development with Existing and Authorized Facilities. Runoff parameters used in ETA's TR-20 models were developed from mapping and information provided by the City of Rockville. Runoff Curve Number (RCN) values, Time of Concentration (Tc) values and Cross Section parameters used in the ETA model are documented in Appendix D of ETA's report. Data for each of the structures modeled came from a number of sources and is not documented as clearly.

Macris, Hendricks and Glascock, P.A.(1999) revised and updated ETA's 1989 TR-20 hydrologic model. Revisions to the model include adding the 6 month, 1-year and 18 month design rainfall values to the model, deleting the 5 year rainfall value from the model, correcting the drainage area of sub-watershed W9 (0.853 to 0.0853 square miles) and adjusting the pattern of subwatershed runoff combinations to provide nodes at or near each of ten historic cross section locations selected for detailed study. Updates to the model included further subdivision of previously undeveloped sub-watersheds to more adequately define current development patterns, runoff flow patterns and existing and potential proposed stormwater management facilities (see Section 3.5 for the results that include the effect of potential stormwater management retrofit sites).

2.3.2 Results

Predevelopment Condition

Only minor revisions were made to ETA's Predevelopment Condition scenario for this study. Input and summary output from the TR-20 model are included in Appendix D. Peak predevelopment discharges for each of the ten historic cross sections and at other selected locations within the watershed are shown in Table 2.6. Values are reported to the hundredth to be consistent with the model output; however, it is important to note that discharge estimates are generally considered to be accurate if they are within 30 percent of the "true" discharge.

Table 2.6 Peak Discharges – Predevelopment Condition

Return Period	**6 Month**	**1 Yr**	**18 Month**	**2 Yr**	**10 Yr**	**100 Yr**	
24 Hour Rainfall	**1.7"**	**2.6"**	**3.0"**	**3.2"**	**5.1"**	**7.2"**	
Location	**Qp-cfs**	**Qp-cfs**	**Qp-cfs**	**Qp-cfs**	**Qp-cfs**	**Qp-cfs**	**TR-20 Reference (Area Sq. Mi.)**
Cross Section 1	1.22	30.71	60.87	79.09	327.03	685.77	Struct 2 Resvor (.55)
Cross Section 2	0.27	6.56	14.80	20.13	100.91	228.32	Struct 6 Runoff (.25)
Cross Section 3	3.00	64.19	127.70	166.99	689.54	1304.63	Struct 6 Addhyd (1.33)
Cross Section 4 & 5	4.33	102.28	205.54	269.45	1061.00	1992.86	Struct 14 Addhyd (2.41)
Cross Section 6	4.42	105.09	211.44	277.37	1084.75	2036.40	Struct 17 Resvor (2.52)
MD Route 28	4.42	105.09	211.09	276.20	1057.52	1988.78	Struct 18 Resvor (2.52)
Cross Section 7 & 8	6.21	124.78	262.90	350.57	1525.58	3093.22	Struct 32 Addhyd (3.83)
Hurley Avenue	0.67	13.92	27.71	36.39	163.35	358.33	Struct 39 Resvor (0.32)
Cross Section 9	7.19	144.52	300.84	399.77	1717.95	3508.21	Struct 43 Addhyd (4.45)
Cross Section 10	8.21	144.87	301.44	400.53	1720.48	3513.43	Struct 43 Addhyd (4.47)
City Boundary	10.79	199.82	383.93	497.75	1886.11	4005.42	Struct 70 Addhyd (6.46)

Existing Development Condition with Existing Structures

Revisions that were made to ETA's Existing Condition scenario included further subdivision of previously undeveloped sub-watersheds. Documentation for Runoff Curve Number (RCN) values, time of concentration (Tc) values, cross section parameters for the new subareas, input and summary output from the TR-20 model are included in Appendix D. Table 2.7 shows the peak discharges for each of the ten historic cross sections and at other selected locations within the watershed. It is of note that the 1-yr and 18-month modeled flows for this scenario are in good agreement with the bankfull flows estimated from the field survey data (see Table 2.1).

Table 2.7 Peak Discharges - Existing Condition with Existing Structures

Return Period	6 Month	1 Yr	18 Month	2 Yr	10 Yr	100 Yr	
24 Hour Rainfall	**1.7”**	**2.6”**	**3.0”**	**3.2”**	**5.1”**	**7.2”**	
Location	**Qp-cfs**	**Qp-cfs**	**Qp-cfs**	**Qp-cfs**	**Qp-cfs**	**Qp-cfs**	**TR-20 Reference (Area Sq. Mi.)**
Cross Section 1	51.10	86.15	128.37	186.45	575.43	1113.15	Struct 2 Resvor (.55)
Cross Section 2	47.25	129.31	172.59	195.14	427.57	701.98	Struct 6 Runoff (.25)
Cross Section 3	67.92	140.60	190.46	271.51	1061.31	1791.14	Struct 6 Addhyd (1.33)
Cross Section 4 & 5	139.19	395.11	572.09	652.96	1318.71	2118.80	Struct 14 Addhyd (2.41)
Cross Section 6	153.87	424.06	568.60	645.37	1349.17	2049.24	Struct 17 Resvor (2.52)
MD Route 28	134.95	407.51	544.37	615.92	1281.57	1957.17	Struct 18 Resvor (2.52)
Cross Section 7 & 8	142.77	429.76	653.00	778.86	2044.48	3385.91	Struct 32 Addhyd (3.83)
Hurley Avenue	6.19	39.15	61.91	74.55	245.56	454.01	Struct 39 Resvor (0.32)
Cross Section 9	156.55	498.93	745.84	887.34	2371.64	3942.21	Struct 43 Addhyd (4.45)
Cross Section 10	157.11	500.74	747.94	889.95	2378.79	3949.74	Struct 43 Addhyd (4.47)
City Boundary	190.59	610.75	874.75	1010.98	2514.83	4140.22	Struct 70 Addhyd (6.46)

Ultimate Development Condition with Existing Structures

For this model run, the ultimate development condition was run with existing structures in place. This will provide a frame of reference to assess the effect that new structures as well as retrofit structures will have on the stream. Table 2.8 shows the peak discharges under ultimate development conditions with existing structures for each of the ten historic cross sections and at other selected locations within the watershed.

Table 2.8 Peak Discharges – Ultimate Condition with Existing Structures

Return Period	6 Month	1 Yr	18 Month	2 Yr	10 Yr	100 Yr	
24 Hour Rainfall	**1.7”**	**2.6”**	**3.0”**	**3.2”**	**5.1”**	**7.2”**	
Location	**Qp-cfs**	**Qp-cfs**	**Qp-cfs**	**Qp-cfs**	**Qp-cfs**	**Qp-cfs**	**TR-20 Reference (Area Sq. Mi.)**
Cross Section 1	76.79	199.33	289.96	330.04	724.98	1270.56	Struct 2 Resvor (.55)
Cross Section 2	109.89	222.21	274.45	300.84	554.63	834.91	Struct 6 Runoff (.25)
Cross Section 3	101.46	258.63	383.74	454.18	1198.66	1909.03	Struct 6 Addhyd (1.33)
Cross Section 4 & 5	193.58	502.87	683.54	732.23	1440.51	2212.93	Struct 14 Addhyd (2.41)
Cross Section 6	209.45	512.80	672.10	721.35	1479.56	2120.98	Struct 17 Resvor (2.52)
MD Route 28	200.61	498.04	645.13	694.15	1396.92	2068.01	Struct 18 Resvor (2.52)
Cross Section 7 & 8	362.52	994.10	1315.28	1437.22	2866.44	4053.09	Struct 32 Addhyd (3.83)
Hurley Avenue	22.06	84.40	127.96	150.21	364.19	653.68	Struct 39 Resvor (0.32)
Cross Section 9	390.18	1102.56	1470.22	1613.44	3309.53	4706.55	Struct 43 Addhyd (4.45)
Cross Section 10	390.73	1104.41	1473.10	1617.20	3316.86	4715.70	Struct 43 Addhyd (4.47)
City Boundary	394.26	1077.45	1438.94	1588.33	3322.75	4918.60	Struct 70 Addhyd (6.46)

2.4 Watts Branch Water Quality

The overall water quality of Watts Branch is an important consideration of the management plan. Water quality concerns include public health issues associated with water contact recreation in the stream, protecting the downstream drinking water supply intake on the Potomac River, and reducing the nutrient load to the Chesapeake Bay. One of the goals of the plan is to reduce the pollutant load associated with stormwater runoff by implementing stormwater retrofits, streambank rehabilitation practices, and pollution prevention outreach techniques.

It is beyond the scope of this project to collect and analyze water quality, macroinvertebrate, or fish samples; however, some data collection and analysis has previously been performed in the Watts Branch watershed. This section provides a brief overview of some of the data collection efforts. (Note, up to eight sampling locations will be monitored for macroinvertebrate community assessment as part of Phase III of the plan development.)

EA Engineering, Science, and Technology, Inc. (1997) summarized historic data collection efforts in Watts Branch as part of an environmental assessment for the City of Rockville's proposed sewer upgrade. Table 2.10 has been adopted from a summary table in EA's 1997 report. In general, the sampling stations on Watts Branch exhibit some degree of impairment from a water quality and fish and macroinvertebrate standpoint. This is consistent with what one would expect to see in an urban stream with impervious cover of about 28 percent.

Table 2.9 Summary of Historic Watts Branch Water Quality, Macroinvertebrate, and Fish Data (Adopted from EA, 1997)

Location	Water Quality	Macroinvertebrates	Fish	Comments	Data Collector
• Upper Watts Branch • Woodley Gardens • Woottons Mill Park • Research Blvd • Lower Watts Branch (Scott Dr.)	• Slightly turbid Acceptable readings for temperature, pH, dissolved oxygen, and conductivity	• Poor • Fair • Poor • Poor • Poor	• Fair • Fair • Fair • Good • Fair	Sampling conducted from March - April 1997; visible signs of channel erosion at all stations	EA Engineering, Science and Technology Inc.
• Woodley Gardens • Lower Watts	No Data	• Poor • Fair	• Good • Fair	Macroinvertebrate sampling conducted in March 1996; fish sampling conducted in July (Woodley) and September (Lower Watts) 1996	Montgomery County DEP
• Watts Branch above College Gardens • King Farm (3 stations)	• Fair to Good • Very Poor to Fair	• Highest quality station of 4 sampled; mayflies and caddisflies present • Some caddisflies and mayflies present	No Data	• Winter 1995, Spring and Fall 1996 • Winter 1995, Spring and Fall 1996	Loiderman and Associates
• Woottons Mill Park	No Data	• Mayflies and caddisflies present	No Data	May, June, and July 1991	MD Dept. of Natural Resources (DNR)
• Woottons Mill Park	• Good (despite urban development)	• Some mayflies and caddisflies present	• Good diversity	October 1990	MD DNR
• Mainstem Watts Branch	Water Quality Index • Good • Excellent • Permissible	No Data	No Data	• 1972 • 1974-1975 • 1976-1979	Montgomery County DEP

2.5 Planning Charette

The Watts Branch study was structured to involve the public at various levels throughout the course of the project, with a strong emphasis on getting early input and involvement from the public in the planning process. This allows for contentious issues to be identified and addressed early in the planning phases and helps identify the important issues are to watershed residents. Establishing stakeholder pride and ownership in the plan leads to a greater chance of project success.

With this in mind, a planning charette with interested stakeholders was sponsored by the City and the Watts Branch Partnership on October 30, 1999, in which the preliminary findings of the geomorphic assessment, stream assessment and retrofit and stream rehabilitation inventories were presented. Approximately 30 people attended the planning charette, representing a variety interests and backgrounds. Stakeholders included citizen associations, interested homeowners, environmental planners, and staff from various agencies in Montgomery County and the City of Rockville. Despite the positive turnout, several key stakeholders were not represented, including utility companies, developers, and office and institutional interests. Keeping these players informed and engaged in the watershed study will be critical to the overall rehabilitation effort in the watershed.

The charette was structured in two parts. The first was comprised of a presentation of the watershed assessment tasks and the findings to date, and the second part involved stakeholders participating, in groups of 5-10 people, in one of three watershed exercises. Where appropriate and feasible, the results of the three watershed exercises have been incorporated throughout the Watts Branch Watershed Plan. For example, the results from the ranking exercise have been factored into the development of a scoring system that will help prioritize retrofit sites. In addition, a basic concept design that one group developed was adopted as the proposed retrofit for the site. The general scenario of each exercise is presented below.

2.5.1 Exercise #1 - Retrofit Ranking for Selected Subwatershed

In this exercise, each group was presented with a subwatershed in Watts Branch with candidate retrofit sites. A summary of subwatershed conditions/characteristics was provided along with the field inventory sheets for each proposed retrofit site. The inventory sheets described the contemplated retrofit, provided a concept sketch, and listed both constraints and opportunities for implementation.

Each group was initially responsible for identifying realistic watershed rehabilitation goals that could be achieved given the current land use and stream conditions. Each group was provided with a “Fact Sheet” summarizing the watershed assessment efforts on Watts Branch to date, and was asked to prepare a list of what they thought might be improved. To facilitate this task, the group was also given templates for “sensitive,” “impacted,” ”restorable” and “non-supporting” streams to provide context on what typical management objectives are. Next, each group was asked to list ten goals that the Watts Branch study should attempt to accomplish.

Perhaps the most challenging component of this exercise was the task of refining a stormwater management site ranking system, scoring individual sites and ranking them in order of highest to lowest score. The exercise used the Rockmead Park tributary, a small portion of the total Watts Branch watershed within the City of Rockville, as the case study.

Specifically, the group was provided with five candidate retrofit sites that were identified within the Rockmead Park tributary as part of a retrofit inventory, and asked to evaluate the potential projects and to develop a ranking system that would assist in the prioritizing of the projects. The ranking scheme was based on such factors as treatment capabilities, physical feasibility, cost, and environmental impacts.

Results

Two groups participated in this exercise, and the goals and priorities they identified were:

- Improve the effectiveness and enforcement of existing regulations (i.e., the mass grading of King Farm was noted)
- Reduce the potential for further channel enlargement by controlling velocities and volumes of stormwater runoff
- Improve the overall ecological conditions in stream reaches from “fair” to “good”
- Promote native vegetation in the riparian corridor
- Improve water quality and incorporate advanced stormwater management techniques on King and Thomas Farms
- Increase public awareness and education with emphasis on changing watershed behaviors
- Create open/green space and passive recreational opportunities

Both groups debated how to most appropriately weight the ranking factors. In general, a greater emphasis was placed on the ability of a retrofit to provide water quality and channel protection. Less emphasis was placed on factors such as cost and impact on natural resource.

2.5.2 Exercise #2 - Public Education and Outreach Program Development

In the second exercise, the group was charged with developing an effective public education and outreach program based on real world constraints such as budget. At the outset of the exercise the group filled out and compared responses to a questionnaire on common polluting behaviors, such as lawn care, pet wastes, and car washing (Swann, 1999). The questionnaire provided an understanding of the obstacles that need to be overcome by proposed programs.

Next, each group was asked to identify which resident behaviors they felt were most important to change, and to develop a media campaign to address it. The challenge was to develop a program with the most significant and long lasting impact. The exercise scenario assumed that the group was attempting to obtain grant funds to finance the education initiative. They were responsible for identifying a target audience, developing a slogan/theme, and determining the media through which the message would be conveyed. To facilitate the exercise, unit costs for various media campaigns were provided along with representative examples of certain approaches. Lastly, the group was challenged to come up with at least one innovative approach to public education and outreach.

Results

There was one group that participated in this exercise. Responses to the questionnaire were varied and largely inconclusive due to the small sample size. Perhaps the most telling result of the survey was that the use of lawn care companies is fairly prevalent and that these companies might be a good group to target for education initiatives. For the media campaign, the group decided to target homeowners with a three-pronged attack on lawn fertilization, pet waste management, and automotive/equipment maintenance. The campaign slogan developed was “We are all part of the problem.” Eddy the fish was designated as the campaign mascot/spokesperson. Public service announcements and refrigerator magnets were the proposed methods of conveying the message.

2.5.3 Exercise #3 - Retrofit Design

The third exercise required participants with a bit more technical experience (i.e., engineers, architects, planners). The goal was to outline a basic conceptual design for a stormwater management retrofit site. The exercise was conducted using one of the retrofit sites identified in the retrofit inventory conducted for Watts Branch watershed. The groups were provided with basic information such as drainage area, impervious cover, soil type, etc. Their challenge was to fill out field retrofit forms with a concept design(s). Guidance for retrofit rules of thumb such as treatment volume and required area were provided.

Each group was provided with the basic guidance that their retrofit strategy should probably place an emphasis on restoring stream channel morphology by placing a priority on retrofits that provide the most storage for channel protection, but also provide water quality controls for pollutant reduction. Some other rehabilitation goals they were asked to consider included: reduce trash in the streams, protect and preserve existing forests and wetlands, maintain existing recreational areas, and protect existing utilities in or near streams from erosion damage. A last constraint that the group was asked to address was to meet watershed protection objectives while minimizing impacts to existing facilities, forests, or other natural features.

Two sites were evaluated in this exercise. The first was a 62-acre catchment near Glenora Park and the second was the 84-acre catchment to the- pond at College Gardens Park.

Results

There were two groups that participated in this exercise. One group developed a concept design for the Glenora Park site and the other group developed a concept design for the College Gardens site. In general, both groups noted the difficulty in fitting in the required target volumes without significantly impacting some existing condition such as recreational space (i.e., playgrounds, ball fields, picnic areas, etc.), forest, or wetlands. In the case of Glenora Park, the group felt that options treating the full target volumes for water quality and channel protection would be too drastic and likely would not be accepted/supported by the local citizens. The College Gardens site had a bit more flexibility and room to work with, and the group proposed to enlarge the pond and relocate some of the impacted play areas.

2.5.4 General Comments From Participants

The stakeholders that participated in the planning charette generated excellent dialogue about important issues with respect to overall watershed protection goals and their priorities in mitigation/rehabilitation efforts.

Based on the charette evaluation forms that were completed and documentation of the discussion, some of the key observations/impressions that participants came away with were:

- It was generally acknowledged that it is extremely difficult to go into developed watersheds and locate stormwater retrofits that are effective without making some difficult decisions about land use and open space.
- Watershed residents indicated a desire to study the issues more closely and to have access to the preliminary findings of the retrofit and stream rehabilitation inventories.
- Some interest was expressed about obtaining water quality data that supplemented the channel erosion data. Citizens are just as concerned about the quality of the runoff as they are about the condition of the stream channel.
- It was noted that it will be important to continue to educate the citizens of the watershed, and to particularly explore methods to get the message out to those who do not attend charettes, workshops, or public meetings.
- Participants expressed a desire to visit some representative sites where retrofits were being proposed.

SECTION 3. STORMWATER RETROFIT OPPORTUNITIES

Ideally, stormwater treatment practices, which are designed to maintain water quality, control flooding, protect stream channels, or meet other watershed goals, are put in place as development occurs. When sites are designed in this way, a plan can be developed with stormwater management in mind by providing the necessary contours, space, and other features necessary to accommodate these practices. Unfortunately, significant portions of Watts Branch were developed with no stormwater treatment practices or facilities that only provide peak discharge controls for larger storm events (e.g., the 2 or 10 year storms) that have little capability to control channel erosion or provide water quality controls. As presented in Section 1, stormwater retrofits are being pursued as one of the tools of the Watts Branch Watershed Management Plan. The primary purpose of the retrofits is to provide channel protection storage to reduce the amount of channel erosion occurring and water quality treatment to reduce the pollutant loading to the stream during stormwater runoff events.

In August 1999, the Center for Watershed Protection, with help from the City of Rockville staff, conducted a retrofit inventory for Watts Branch within the City of Rockville. This section describes the process of locating and identifying potential stormwater retrofits for Watts Branch. Figure 3.1 illustrates the location of the candidate retrofit sites. Appendix E contains the full retrofit inventory sheets where each site is described in detail and a conceptual sketch of the most likely retrofit option is presented.

3.1 The Watershed Retrofitting Process

Watershed retrofitting should be viewed as a long term process involving a myriad of disciplines from natural resources management, to engineering design, to public policy and education. Since every watershed is different, it is challenging to break such a complicated process into a step-wise, "cookbook" approach. However, there are eight basic elements that are key to a successful retrofitting effort. Table 3.1 presents this step-by-step approach to stormwater retrofitting developed by the Center for Watershed Protection staff over the past several years. The table also indicates the status of each step at this point in the development of the watershed management plan for Watts Branch.

Phase I of the study investigated all possible stormwater opportunities and prioritized them. The results of the ranking are presented in Section 3.4. Under Phase II of the project, the highest ranking retrofits were carried forward to the conceptual design stage (see step 5, in Table 3.1).

Retrofits come in many shapes and sizes, from large regional retention ponds that provide a variety of controls, to small on-site facilities providing only water quality treatment for smaller storms. Usually at least some kind of practice can be installed in almost any situation. But fiscal constraints, pollutant removal capability, practical physical limitation and watershed capture area must all be carefully weighed in any retrofit selection criteria. For Watts Branch we placed an emphasis on identifying locations and practices that have the capability to manage and treat larger drainage areas, have a lower maintenance burden, and have a proven track record for effective pollutant removal capability.

Figure 3.1 Candidate Retrofit Sites

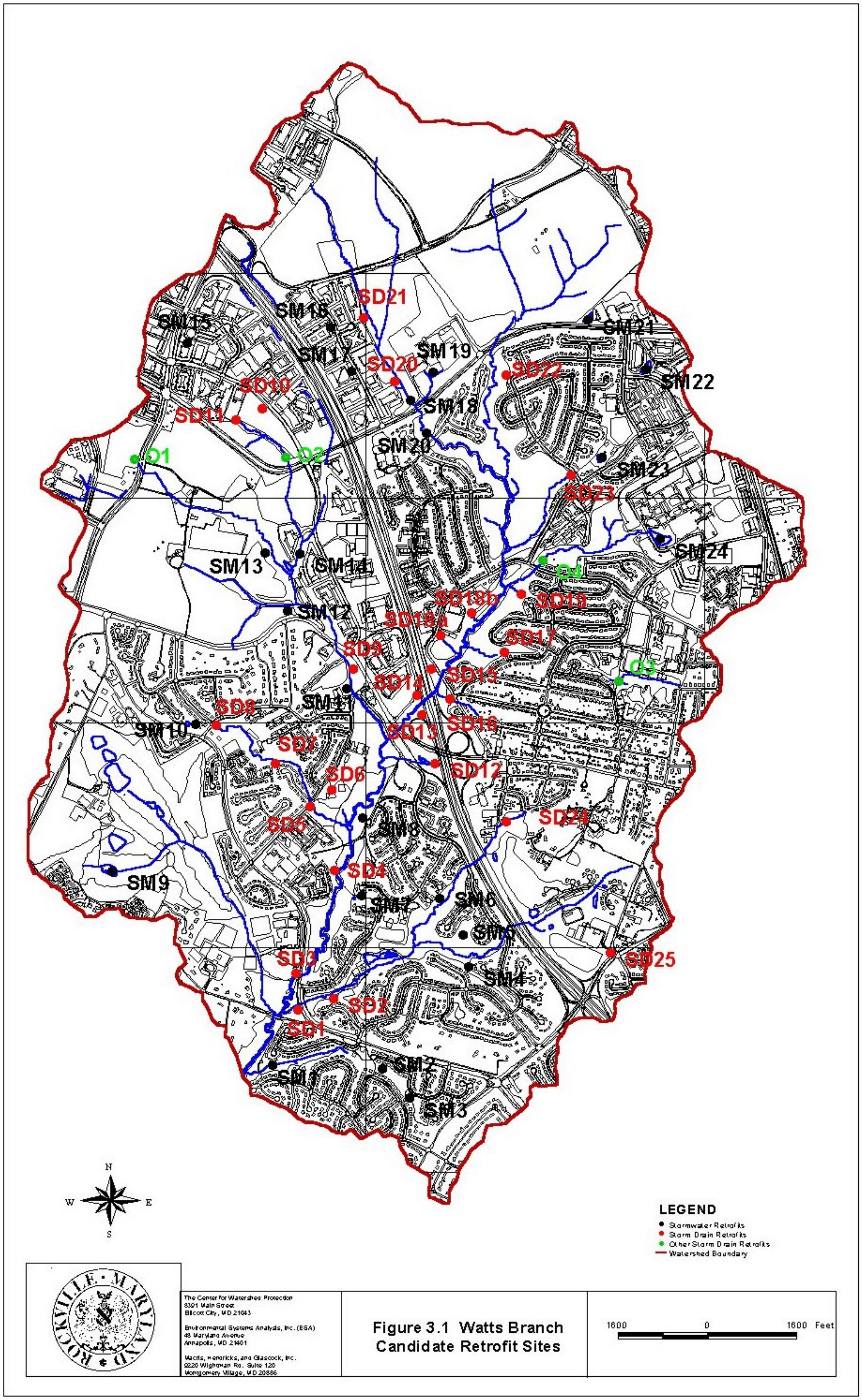


Table 3.1 Basic Elements of a Stormwater Retrofitting Implementation Strategy

Step	Element	Purpose	Status
1.	Preliminary Watershed Retrofit Inventory	Identify potential retrofit sites	✔
2.	Field Assessment of Potential Retrofit Sites	Verify that sites are feasible and appropriate, produce concept designs.	✔
3.	Prioritize Sites for Implementation	Set up a priority for implementing future sites	✔
4.	Public Involvement Process	Solicit comments and input from the public and adjacent residents on potential sites	✔
5.	Retrofit Design	Prepare construction drawings for specific facilities	✅
6.	Permitting	Obtain the necessary approvals and permits for specific facilities	✅
7.	Construction Inspections	Ensure that facilities are constructed properly in accordance with the design plans	-
8.	Maintenance Plan	Ensure that facilities are adequately maintained	-

✔: Step is complete
✅: Step has been initiated but is not yet complete
- : Step has not been started

The first step in retrofit implementation is the process of identifying feasible and appropriate sites. This involves a process of identifying as many potential sites as rapidly as possible. The best retrofit sites fit easily into the existing landscape, are located at or near major drainage outlets or existing stormwater control facilities, and are easily accessible. For example, the watershed area southwest of I-270 contains several existing dry stormwater detention facilities that were constructed in the past for flood control. In the older neighborhoods northeast of I-270, there are several stormwater outfalls and other water features where suitable opportunities exist for retrofits. Table 3.2 lists some of the most likely spots for locating facilities and some common applications.

Table 3.2 Some of the Best locations for Stormwater Retrofits

Location	Type of Retrofit
Existing stormwater detention facilities.	Usually retrofitted as a wet pond or stormwater wetland capable of multiple storm frequency management
Immediately upstream of existing road culverts	Often a wet pond, wetland, or extended detention facility capable of multiple storm frequency management
Immediately below or adjacent to existing storm drain outfalls	Usually water quality only practices, such as sand filters, vegetative filters or other small storm treatment facilities
Directly within urban drainage and flood control channels	Usually small scale weirs or other flow attenuation devices to facilitate settling of solids within open channels
Highway rights-of-way and cloverleaves	Can be a variety of practices, but usually ponds or wetlands
Within large open spaces, such as golf courses and parks.	Can be a variety of practices, but usually ponds or wetlands capable of multiple storm frequency management
Within or adjacent to large parking lots	Usually water quality only facilities such as sand filters or other organic media filters (e.g., bioretention)

The first step is completed in the office using topographic mapping (the City's 5' contour interval GIS mapping is quite satisfactory), low altitude aerial photographs, the storm drain master plan, and land use maps. Scouting for potential candidate sites follows the guidance discussed above in Table 3.2. Two important tasks need to be undertaken before venturing into the field. First, the drainage area to each retrofit is delineated and second, the potential surface area of the facility is measured. The drainage area is used to estimate a potential capture ratio. This is the percentage of the overall watershed that is being managed by all retrofit projects. The potential surface area is used to compute a preliminary storage volume of the facility. A short cut storage volume can be computed by multiplying two-thirds of the facility surface area times an estimated depth ($\frac{2}{3} \cdot SA \cdot d$). These two pieces of information are used as a quick screening tool. In general, an effective retrofitting strategy attempts to capture at least 50% of the watershed area. A minimum water quality target storage volume for each retrofit is equal to approximately ½ inch per impervious acre[1]. For channel protection purposes, a target storage volume is to provide 24-hour extended detention for the 1-year return frequency storm (the 1-year storm for the Watts Branch vicinity is approximately 2½ inches).

[1] Although the recently adopted Maryland Department of Environment water quality regulations require treatment of approximately 1" of runoff per impervious acre, the Center and the City agreed that this is unmanageable in retrofit situations within the City. Available space, tree preservation concerns, and resident support made the ½ inch target a better fit for the community and more realistic to achieve.

The candidate retrofit sites are then investigated in the field to verify that they are feasible. This field investigation involves a careful assessment of site specific information such as identifying the presence of sensitive environmental features, the location of existing utilities, the type of adjacent land uses, the condition of receiving waters, construction and maintenance access opportunities, and most importantly, whether or not the contemplated retrofit will actually work in the specified location. A conceptual sketch is prepared, photographs are take, and the retrofit inventory form is completed for each site (see Appendix E).

3.2 Watts Branch Retrofit Inventory and Assumptions

The Watts Branch retrofit inventory was conducted during the summer of 1999. The preliminary office investigation (using aerial photography, planimetric base mapping, and storm drain mapping) identified 54 candidate stormwater retrofit sites (see Figure 3.1 for locations). Screening criteria were employed to target larger outfalls and existing ponds so that the number of candidate sites to investigate would be reasonable and the total watershed area potentially addressed was maximized (as stated previously, a goal of the retrofitting process is to capture at least 50% of the watershed area). The screening criteria generally meant that existing underground storage practices or smaller parking lots would not be evaluated, since the typical contributing drainage area is less than 5 acres. The ideal target for each site was to provide 100% of both the water quality and channel protection storage. However, based on the observations and analysis associated with the channel geomorphic assessment (i.e., that most of the channel was experiencing significant and active erosion), a slight bias towards providing channel protection storage volume was instituted. Water quality only facilities were not generally considered due to high cost-benefit ratio to the overall watershed.

Twenty-six of these sites are at, or immediately adjacent to, a storm drainage outfall of at least 30" diameter (designated as "SD" sites). The 30" pipe size limit was selected as the screening level to obtain a reasonable minimum drainage area for candidate sites. Another 24 candidate sites are at existing pond sites, generally stormwater detention or retention facilities (designated as "SM" sites). In general, candidate stormwater sites have a drainage area of at least seven to ten acres (again to obtain a reasonable minimum area for candidate sites) and were constructed prior to 1993. For example, existing stormwater facilities associated with the King Farm and Rose Hill developments were not investigated, as these facilities were designed and constructed based on more advanced water quality criteria. It was assumed that these facilities were generally providing their intended water quality control. The remaining four sites (designated as "other" or "O") are at locations with a significant drainage area upstream from an existing road culvert or at the intake of a major drainage system.

Of the 54 original candidate sites, 17 were deemed infeasible or impractical based on the field reconnaissance (ten "SD" sites, four "SM" sites, and three "O" sites). The reasons for dropping a site from further consideration generally were because of too little available area, poor or impractical construction and/or maintenance access, or the presence of existing natural features such as non-tidal wetlands. Appendix E describes in detail the reasons why particular sites were dropped from further consideration.

3.3 Ranking System

A retrofit ranking system was developed to provide a quantitative evaluation to prioritize candidate stormwater retrofit sites. The criteria and the assigned weighting were developed based on best professional judgement, input from the Watts Branch Partnership, City staff and experience. The following discussion provides the rationale for selecting the factors and assigning the weights.

The retrofit ranking system evaluates sites based on criteria in two major categories – a "technical features" category and an "environmental and community goals" category. The two categories help determine how well a project meets the water resources objectives at a location as well as how it satisfies community concerns. The technical features category contains eight ranking criteria:

- Impervious area treated
- Percent of channel protection target volume treated
- Percent of water quality target volume treated and pollutant load reduction
- Project cost
- Land ownership and availability
- Ease of access
- Future maintenance burden
- Impact on utilities

The environmental and community goals category contains four ranking criteria:

- Forest and tree preservation
- Recreation preservation
- Wetlands preservation
- Community acceptance

The specific groupings of each criteria are presented below in Table 3.3

Table 3.3 Retrofit Ranking Criteria

Stormwater Management and Site Technical Features Criteria

1. Impervious Area Treated – How many acres of paving or rooftops drain to this facility?

0 < drainage area ≤ 30 acres

30 < drainage area ≤ 50 acres

50 < drainage area ≤ 70 acres

70 < drainage area ≤ 90 acres

Drainage area > 90 acres

2. % of Channel Protection Target Volume (2.5"/impervious acre) Treated - Based on the volume of runoff which needs to be controlled to reduce downstream erosion, how much of this runoff will fit into the facility?

0%< capture ≤ 20%

20%< capture ≤ 40%

40%< capture ≤ 60%

60%< capture ≤ 80%

80%< capture ≤ 100%

3. Water Quality Target (consists of two parts)

3a. % of Water Quality Target Volume Treated - Based on the volume of runoff which needs to be controlled to treat 90% of the average annual stormwater runoff. How much of this runoff will fit into the facility?

0%< capture ≤ 20%

20%< capture ≤ 40%

40%< capture ≤ 60%

60%< capture ≤ 80%

80%< capture ≤ 100%

3b. Pollutant Load Reduction: TSS & TP – How effective is the proposed SWM method at removing suspended solids and phosphorus, two indicators of urban pollution?

Open channel/plunge pool/outfall treatment

Dry ED pond with micropool

Wet ED pond or wetland marsh

Bioretention or other filtration practice

4. Project Cost ($/acre tributary to facility) - Costs include consideration of design, permitting and construction. How much will the facility cost, taking into account the size of the drainage area?

> $5,000/acre of drainage area

$4,000 ≤ project cost < $5,000

$3,000 ≤ project cost < $4,000

$2,000 ≤ project cost < $3,000

$1,000 ≤ project cost < $2,000

< $1,000/acre of drainage area

5. Ownership and Availability – How difficult is it to secure use of the site for a modified or new SWM facility?

Private site, no easement

Private site with existing SWM facility OR public site with no current SWM facility

Public site with current SWM facility

6. Access – How disruptive or difficult will it be to move construction or maintenance vehicles to and from the site?

Poor – examples: requires easements through private lots, removes many trees, grade problems.

Good

Excellent – examples: easily constructed or good existing access path across common open space or public land.

7. **Maintenance Burden – Based on SWM method – assumes proper pre-treatment and includes long term maintenance needed to keep/restore function)**

   High maintenance (e.g., open channels, plunge pools, outfall treatments, dry ED ponds, bioretention, filtration) – needs debris/sediment removal more frequently than once/year; will fail to function if not maintained and/or must be rebuilt to restore function once it fails (e.g., filtration).

   Medium maintenance (e.g., dry ED ponds with micropools) – needs debris/sediment removal more than once a year.

   Low maintenance (e.g., wet ponds, wetland marshes) – infrequent maintenance; will not fail for long period of time even without regular maintenance

8. **Utilities Impact – How difficult will existing utilities such as sewer or gas lines make proposed SWM construction?**

   Major impacts – underground line must be relocated (> $20,000 cost) or site layout is significantly constrained by utilities

   Minor impacts – site layout is slightly constrained by utilities or project requires minor relocation (< $20,000 cost)

   No impacts

Environmental and Community Goals Criteria

1. **Forest and Tree Preservation – How does this project affect trees within the overall site? (Note: significant trees are defined in the City's Forest Conservation Manual as 24" diameter within forests or 12" diameter outside of forests.)**

   Loss of > 2.0 acres of forest or 80%-100% of existing significant trees from site

   Loss of 1.5 to 2.0 acres of forest or 60%-80% of existing significant trees from site

   Loss of 1.00 to 1.5 acres of forest or 40%-60% of existing significant trees from site

   Loss of 0.5 to 1.00 acres of forest or 20%-40% of existing significant trees from site

   Loss of up to 0.5 acres of forest or up to 20% of existing significant trees from site

   No loss of forest or existing trees

2. Recreation Preservation – How does this project affect formal or informal recreational opportunities (both existing and planned future recreational features) at the site?

Total loss of currently programmed major athletic field or major recreational facility (e.g., Rec. Center) without possibility to mitigate the loss at any time

Total loss of currently programmed major athletic field or major recreational facility (e.g., Rec. Center) with the possibility to mitigate the loss within the normal 5-year projection of the Capital Improvement Program

Total loss of currently programmed minor athletic field or minor recreational facility (e.g., shelter, play equipment over $100k, etc.) without possibility to mitigate the loss at any time

Total loss of recreational amenities or open space (that is not programmed) without possibility to mitigate the loss within the normal 5-year projection of the Capital Improvement Program

No loss of existing athletic fields, recreational facilities, or programs

3. Wetlands Preservation – How does this project affect known or apparent wetlands at the site?

Net loss of > 0.50 acres of wetland

Net loss of 0.25 to 0.50 acres of wetlands

Net loss of 0.12 to 0.25 acres of wetland

Net loss of up to 0.12 acres of wetland

Either net gain or no loss of wetlands

4. Community Acceptance (<u>pick all that apply</u>)

Facility fits into scale of overall location and character of site

Not visible from nearby houses

Not visible from nearby play areas (tot lots, recreation centers, pools, etc.) – only applies to wet ponds or other deep water practices for safety concerns

Site already has a stormwater practice located on it

The Center adopted a ranking approach based on a benefit/cost concept, whereby criteria were defined based on whether they generate benefits or costs. For example, impervious area treated and pollutant load reduction were considered "benefits" of a retrofit, while the project cost, access, and maintenance burden were considered "costs" associated with the retrofit. A "net benefit" was generated by summing the positive points awarded to benefits and negative points awarded to costs criteria. In addition, a benefit/cost ratio was calculated which provided a relative index for each retrofit site (i.e., identifies sites with the most "bang for the buck"). An iterative process was used to arrive at the final ranking that involved input from and participation with the Watts Branch Partnership.

A series of five scenarios were evaluated with different point weighting to determine the sensitivity of the ranking scheme. The five scenarios included:

Scenario 1. Original City ranking, which placed equal weight on the technical and community based criteria.

Scenario 2. Reweighted scores that gave greater weight to treated area, channel protection, water quality, and forest preservation and less weight to all other criteria.

Scenario 3. Reweighted scores that gave greater weight to treated area, channel protection, water quality, and forest and wetland preservation and less weight to all other criteria.

Scenario 4. Reweighted scores that gave greater weight to treated area, channel protection, water quality, recreation, and community acceptance and less weight to all other criteria.

Scenario 5. Reweighted scores that gave greater weight to the water quality and channel protection criteria as a function of total impervious area treated (i.e., those sites that treat more impervious area was weighted more heavily). In addition, greater weight was given to forest preservation.

Scenario 5 was the Center's recommended scenario (and ultimately the agreed approach by the City and Partnership), as it reflected a weighting that places more emphasis on a site's ability to provide water quality and channel protection benefits. Based on the Center's past experience and best professional judgement, we feel that these criteria merit a greater emphasis and are key to meeting the overall goals of the Watts Branch Watershed Plan.

3.4 Priority of Sites Based on Ranking System

To simplify the presentation of the sensitivity analysis, the Center focused on the relative ranking of the benefit/cost ratio of each site for the five scenarios described above. Table 3.4 presents the results of the analysis. The table has been sorted based on the ranking of Scenario 5, where sites are listed from highest to lowest (i.e., best to worst) benefit/cost ratio rank.

As can be seen in Table 3.4, the top 15 ranked sites are shared in most scenarios but their rank order often differed. In a few cases there are large variations between one or more of the scenario ranks for a given site. For example, site SM-16 is ranked 15 under the City's scenario (Scenario 1), but is ranked between 24 and 30 in the other four scenarios. This is due to the fact that this site received favorable scores for the four community-based criteria (i.e., low "costs") under the City's point system. These four criteria make up over 60% of the "costs" associated with the project. Under the other four scenarios, where water quality related criteria are given more weight, and some of the community-based criteria are reduced in weight, the rank of site SM-16 drops. Similar explanations apply to the other sites where large variations in rank exist.

Table 3.4 Retrofit Ranking Results

Cost/Benefit Ranks

Site ID	City Scores Scenario 1	Reweighted Scenario 2	Reweighted Scenario 3	Reweighted Scenario 4	Reweighted Scenario 5	Special Notes
SM-8	2	1	1	9	1	*
SM-24	1	3	3	2	2	*
SM-1	6	4	4	3	3	
SM-3	4	5	5	7	4	
SM-22	2	2	2	1	5	*
SD-12	5	9	8	12	6	
O-3	13	14	12	18	7	
SM-23	9	6	7	8	8	
SD-8	24	16	17	23	9	
SM-9	7	7	6	6	10	*
SM-20	14	8	10	4	11	
SM-18	22	10	11	5	12	
SD-24	28	13	14	13	13	
SM-14	16	15	15	11	14	
SM-19	23	25	33	16	15	*
SD-22	20	23	25	20	16	**
SD-6	19	19	20	26	17	**
SD-16	26	24	26	24	18	**
SM-21	11	20	16	15	19	**
SM-2	8	12	9	14	20	**
SM-10	17	22	22	22	21	
SM-4	18	17	18	17	22	
SD-15	29	28	31	27	23	
SD-9	26	27	29	28	24	
SD-18b	32	21	21	21	25	
SM-7	12	18	19	19	26	
SM-6	10	11	13	10	27	
SD-7	31	26	28	29	28	
SD-19	35	32	35	34	29	
SM-16	15	29	24	25	30	
SD-2	36	31	27	36	31	
SD-4	34	32	34	32	32	
SM-15	25	35	32	31	33	
SD-13	33	36	36	33	34	
SM-17	21	34	30	30	35	
SD-18a	30	30	23	35	36	
SD-1	37	37	37	37	37	

Notes:
Scenario 1 = Original City ranking, adjusted to a one-dimensional score using the benefit/cost approach.
Scenario 2 = Greater weight to treated area, Cpv, water quality, and forest preservation and de-emphasis of all other criteria.
Scenario 3 = Greater weight to treated area, Cpv, water quality, and forest and wetland preservation and de-emphasis of all other criteria.
Scenario 4 = Greater weight to treated area, Cpv, water quality, recreation, and community acceptance and de-emphasis of all other criteria.
Scenario 5 = Greater weight to the water quality and Cpv criteria as a function of total impervious area treated (i.e., those sites that treat more impervious area will be weighted more heavily). The remaining criteria under this scenario are the same as Scenario 2.

Special Notes:
Cpv = channel protection storage
* = Site already provides some level of water quality and channel protection volume.
** = Site merits consideration if "*" sites are deemed lower priority due to already good water quality and/or channel protection benefits (i.e., at City's discretion).

It is of note that five of the top 15 sites (all existing stormwater management facilities) already provide some level of water quality and/or channel protection benefits; therefore, they tend to receive higher “benefit” points than the other sites. These sites are identified by an asterisk in the last column of Table 3.4. Since these sites are already providing a certain level of treatment, the City may deem them to be lower in priority than some of the other sites. To account for this, five additional sites (rank 16-20) have been identified as candidates to replace the asterisk sites. These alternative sites are identified by a double asterisk in the last column of Table 3.4.

Eighteen of the top 20 stormwater retrofit sites were ultimately selected to proceed to the conceptual design level, after review and discussion between City staff, the Partnership and the Center. Table 3.5 presents the sites along with their rank, proposed stormwater treatment practice, tributary drainage area, and impervious area treated.

Table 3.5 Stormwater Retrofit Sites Identified for Concept Design

Site ID	Rank	Stormwater Treatment Practice	Tributary Drainage Area (Acres)	Impervious Area Treated (Acres)
SM-8	1	modify pond bottom and add forebays	49	13
SM-24	2	modify existing wet ED pond	123	68
SM-1	3	ED with micropool	80	18
SM-3	4	ED with micropool	88	19
SM-22	5	modify outlet to provide channel protection storage	15	12
SD-12	6	ED with micropool	27	9
O-3	7	shallow marsh wetland	53	16
SM-23	8	wet pond	84	44
SD-8	9	wet pond	181	45
SM-9	10	modify existing storage and provide wet swale	46	9
SM-20	11	ED with micropool	349	54*
SM-18	12	ED with micropool	332	48*
SD-24	13	ED with micropool	68	20
SM-19	15	ED with micropool	18	10
SD-22	16	shallow marsh wetland	31	8
SD-6	17	ED with micropool	39	10
SD-16	18	ED with micropool	37	9
SM-2	20	ED with micropool	17	4

Notes: ED = extended detention

* = Area treated does not include upstream King Farm drainage.

3.5 Recommended Stormwater Management Projects

The following summaries describe the SWM projects approved in the 2001 Watts Branch Watershed Study. Together, they will provide full or partial treatment of 1,087 acres of drainage area, equivalent to about 26% of the City's portion of the Watts Branch watershed. State-of-the-art SWM at the King Farm and Fallsgrove developments will provide treatment for an additional 800 acres. Together, this will offer modern SWM treatment to approximately 45% of the City's Watts Branch watershed. A condensed tabular summary of the projects is provided in Table 3.6 at the end of the short descriptions.

ID: SM1
Name: Horizon Hill #3
Type: Dry Pond with Micropool
Drainage Area = 185 acres

Concept: This existing dry pond is located in Horizon Hill Park between Starlight Court and Sunrise Drive. It would receive a forebay east of the playground and a micropool next to the dam, ranging in depth from a few inches at the edges to 4 feet deep at the center. These pools would help settle out sediment and prevent clogging of the pond's control structures. Grading would be limited to the pool areas; the stream valley between the pools would temporarily pond water for up to 24 hours after storms, but would remain as undisturbed shrub or wooded wetlands. The existing corrugated metal risers would be replaced with concrete control structures to provide the appropriate release rates. This pond will be designed in conjunction with Horizon Hill # 1 and #2 (SM3 and SM2) to work in series.

Advantages: Preserves natural stream valley setting and enhances wetlands; improves appearance of control structures; achieves full SWM control

Disadvantages: Grassed areas of park converted to shrubs/woods; clears about 9 trees bigger than 8" diameter; clearing may be visible from 13 houses

ID: SM2
Name: Horizon Hill #2
Type: Dry Pond with Micropool
Drainage Area = 105 acres

Concept: This existing dry pond, located in Horizon Hill Park between Pebble Ridge Court and Glastonberry Road, would receive a single micropool upstream of the dam ranging in depth from a few inches at the edges to 4 feet deep at the center. Grading would be limited to the pool area; the stream valley upstream of the pool would temporarily pond water for up to 24 hours after storms, but would remain as undisturbed shrub or wooded wetlands. The existing corrugated metal risers would be replaced with concrete control structures to provide the appropriate release rates. This pond will be designed in conjunction with Horizon Hill # 1 and #3 (SM3 and SM1) to work in series.

Advantages: Preserves natural stream valley setting and enhances wetlands; improves appearance of control structures; achieves full SWM control

Disadvantages: Grassed areas of park converted to shrubs/woods; clears about 6 trees bigger than 8” diameter; clearing may be visible from 9 houses

ID: SM3
Name: Horizon Hill #1
Type: Dry Pond with Micropool
Drainage Area = 88 acres

Concept: This existing dry pond, located in Horizon Hill Park between Longhill Drive, Richview Court and Glastonberry Road, would receive three permanent pools (two forebays and a micropool) ranging in depth from a few inches at the edges to 3-4.5 feet deep at the center, depending on the pool. The pools would be located at the end of storm drain pipes flowing into the pond as well as upstream of the dam. Most of the area would be graded, then restored as shrub or wooded wetlands except for the permanent pools and the central stream channel. The existing corrugated metal risers would be replaced with concrete control structures to provide the appropriate release rates. This pond will be designed in conjunction with Horizon Hill # 2 and #3 (SM2 and SM1) to work in series.

Advantages: Preserves natural stream valley setting and enhances wetlands; improves appearance of control structures; achieves full SWM control

Disadvantages: Grassed areas of park converted to shrubs/woods; clears about 15 trees bigger than 8” diameter; clearing may be visible from 9 houses

Horizon Hill #1,2 & 3 Recommendation: The Horizon Hill ponds were built in 1977. The majority of residents who commented on the Horizon Hill ponds requested that the existing corrugated metal pipe (CMP) risers be replaced to improve the appearance. Since these risers are about 25 years old, they will be nearing the end of their life expectancy over the next ten years. Staff therefore recommends replacing the risers with concrete structures. The concrete may be tinted to help the structures blend into the surroundings. The CMP barrels through the dams should also be inspected during final design, and rehabilitated or replaced, if needed, to extend their life. The existing dams should also be inspected and trees removed if required by dam safety regulators.

All of the Horizon Hill retrofits will require state/federal permits. The wetland/waterway regulatory agencies visited the SM1 site in November, 2000, as representative of these projects. Their recommendations included investigating a riser design that would maintain fish passage through the pond’s barrel, if at all possible. They also suggested that the City consider wider shallow marsh areas in the permanent pools for enhanced habitat value. The City will need to justify the on-line concepts at the permitting stage by demonstrating the lack of off-line alternatives for the forebay cells and for the ponds themselves. However, this must be weighed against the greater disturbance to the park by placing a plunge pool at each storm drain outfall.

In the early 1980s, a paved pedestrian path was added along the southern boundary of Horizon Hill Park. Much of it is within the existing 2-year flooding areas from each of the SWM ponds. It is chronically damp or has puddles at certain points from a combination of low spots on the path, backwater from ponding in the SWM facilities and drainage from adjacent lots. The Department of Recreation and Parks (R&P), as well as several residents, have requested that drainage along this path be improved when the ponds are retrofitted. Given the narrowness and relatively gentle slopes of the stream valley, the path's current location will always be prone to frequent flooding. Although elevating the path above the 10-year water surface elevation will not be possible as requested, DPW will work with R&P to make the path more usable by improving drainage and regrading as much as possible without disturbing nearby trees.

The SWM concept also suggested converting the SWM basin areas from mowed grass to a shrub/forested wetland, both for better filtration of overflow storms and for habitat improvement. These areas already exhibit wetland characteristics and a 1992 drainage project was built in Horizon Hill #1 to dry out the bottom of the pond. Reclaiming the stream valley as a natural ecosystem would be an environmental benefit to the Watts Branch watershed and would create a more wooded backdrop for the residents along Horizon Hill Park. The City Forester also recommended using the Horizon Hill Park as a reforestation area. A 10-20 foot area near the pedestrian path should be maintained in grass for dogwalkers and other residents who wish to enjoy the park. The renaturalization may also reduce the amount of trash and yard trim dumping cited by several residents as a chronic problem in the park. This issue should be discussed further with local residents at the final design stage to determine the level of passive recreation in the park. The SWM projects are workable independant of the conversion from grass to shrub/forest.

ID: SM-8
Name: Aintree Pond
Type: Shallow Marsh
Drainage Area = 53 acres

Concept: This existing wetland marsh SWM pond would have minor modifications to the concrete control structure which drains the pond to adjust the 1-year, 24-hour extended detention release rate for better erosion control. Some minor regrading is recommended at the storm drain inflows to the pond to create sediment forebays which will prevent sediment from spreading evenly throughout the pond. This would result in a planted peninsula between each inflow point and the control structure, thus adding to the vegetated appearance of the marsh.

Advantages: Accelerates transition to final marsh appearance; reduces future maintenance problems and avoids future mass disturbance of wetland plants for cleanout of pond

Disadvantages: requires additional construction activity in neighborhood; some existing wetland plants will be disturbed and will require several growing seasons to re-establish on the peninsulaes

Recommendation: Staff continues to work with local residents on the existing pond's appearance and wetland marsh design. Concerns focus primarily on plant placement and selection, whether the pond is supporting a large mosquito population, and the presence at times of trash, algae and duckweed. In 2001, staff met with the community to review several alternatives to enhance the pond's appearance. Most of the residents were satisfied with the pond's appearance and asked that it not be changed further at this time. The community decided to evaluate the pond's appearance in 2003 so that the landscaping can mature and fill in naturally. If the appearance does not meet the community's expectations at that time, staff will consider modifications to the pond, including additional landscaping, regrading the pond bottom, adding boulders along the pond's edge and riser modifications. DPW successfully tried an algae suppression program in the summer of 200, using barley bales staked into this pond to reduce an algal bloom. The City will also need to continue educating residents to the benefits of wetland ecosystems.

ID: SM-9
Name: Lakewood Country Club
Type: Wet Pond
Drainage Area = 46 acres

Concept: This existing wet pond on the south side of the golf course already functions as a SWM pond. It is maintained by the City and is within a public SWM easement since it receives offsite drainage from the National Lutheran Home. Minor modifications are proposed, including a storm drain outfall relocation, addition of a forebay, and changes to the control structure to provide the appropriate release rates.

Advantages: simple, low-cost retrofit; no change in appearance, achieves full SWM control

Disadvantages: construction will disrupt golf course

Recommendation: This project will require coordination with the Country Club Groundskeeper to minimize turf damage and disruption to golf course usage during construction.

ID: SM-18
Name: 270 Industrial Park Pond
Type: Dry Pond with Micropool
Drainage Area = 322 acres

Concept: This existing dry pond would be modified to add two small permanent pool forebays and a permanent micropool upstream of the gabion weir control structure, and to modify the outflow system by adding a metal or concrete riser to prevent clogging and provide the appropriate release rates. This pond will be designed in conjunction with SM-20 (Carnation Drive) and SM-19 (PEPCO) to work in series.

Advantages: partial improvement of SWM control

Disadvantages: space constraints and nearby office building elevation limit expansion due to potential flooding; micropool design must avoid existing sanitary sewer through center of pond.

Recommendation: This retrofit will require state/federal permits. The wetland/waterway regulatory agencies viewed this site in November, 2000. The floodplain upstream of the gabion wall appears to be palustrine forested wetlands, but not of high quality (no apparent springs or seeps, no unusual habitat). Since the existing stream channel is fairly shallow now, the agencies recommended that the west side of the overbank area be excavated to form a shallow marsh offline, but parallel to, the stream channel. A diversion weir at the upstream pond limit would divert stormflows into the offline depression, which would tie back into a micropool at the new low-flow pipe in the gabion wall. This would replace the online forebays, thus maintaining more open stream channel for fish passage and creating more diverse wetland habitat.

The City Forester recommends that the more open area upstream be investigated at final design. Achieving water quality/forebay storage in this area would lessen the forest clearing needed closer to the control structure. This will be assessed after a complete Natural Resources Inventory, including trees and wetlands, is done.

ID: SM-19
Name: PEPCO Pond
Type: Dry Pond with Micropool
Drainage Area = 19 acres

Concept: This existing dry pond would be modified to add two small permanent pool forebays and a permanent micropool upstream of the control structure, and to modify the control structure to provide the appropriate release rates. This pond will be designed in conjunction with SM-20 (Carnation Drive) and SM-18 (270 Industrial Park) to work in series.

Advantages: partial improvement of SWM control

Disadvantages: space constraints limit expansion

Recommendation: At this time, the City does not anticipate funding this private retrofit. In the event of redevelopment, the City will work with PEPCO to facilitate this project, perhaps through PEPCO's environmental improvements program.

ID: SM-20
Name: Carnation Drive
Type: Dry Pond with Micropool
Drainage Area = 358 acres

Concept: This existing dry pond between Aster Boulevard and Larkspur Terrace would be modified to add two permanent pool forebays and a micropool upstream of the existing gabion wall, and to modify the outflow system by adding a concrete control structure to prevent clogging and provide the appropriate release rates. The stream channel would be diverted towards the east side of the existing pond into the micropool area. Undisturbed woods would remain in the west side of the pond, although they would experience temporary ponding for up to 24 hours after storms. This pond will be designed in conjunction with SM-18 (270 Industrial Park) and SM-19 (PEPCO) to work in series.

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Advantages: partial improvement of SWM control; will help reduce erosion problems immediately downstream

Disadvantages: Approximately 1 acre of forest clearing required; clearing will be visible from 9 houses; micropool design must avoid existing sanitary sewer through center of pond.

Recommendations:

The Partnership recommended that the upstream forebay (closest to Gude Drive) be omitted, if possible, at final design to reduce necessary clearing. This forebay may be unnecessary given the sediment/trash removal in the I-270 Industrial Park pond immediately upstream of Gude Drive on this tributary. At final design, the consultant should investigate this and determine whether this will result in a significantly smaller limit of disturbance. The combining of the western forebay and the micropool should also be investigated at final design in an effort to reduce clearing. Final grading needs to provide positive drainage to the existing stream channel that remains within the pond basin; it is expected that this will revert to a wetland condition. A wooded buffer should also be maintained between the pond and the adjacent house to the north on Carnation Drive.

This retrofit will require state/federal permits. The wetland/waterway regulatory agencies will probably have similar comments regarding offline permanent pools offline as for 270 Industrial Park. However, Carnation Drive has existing fish passage barriers both at Gude Drive and Carnation Drive. The existing sewer line placement also constrains alternate flowpaths. Offline water quality pools may not be as feasible or necessary in this pond as in the 270 Industrial Park site. The City will work with the regulatory agencies at final design to resolve these issues.

ID: SM-22
Name: College Gardens Office Park
Type: Wet Pond
Drainage Area = 15 acres

Concept: This existing SWM wet pond, located within a private office complex would be modified to add a forebay and change the control structure to provide the appropriate release rates. A baffle would also lengthen the flow path within the pond.

Advantages: simple, low-cost retrofit

Disadvantages: private pond; small drainage area makes this minimally effective for overall watershed improvements unless combined with College Gardens Park project.

Recommendation: At this time, the City does not anticipate funding this private retrofit, but will work with the owner to facilitate this project. The owner's management company has discussed the possible retrofit with the City.

ID: SM-23
Name: College Gardens Park Pond
Type: Wet Pond
Drainage Area = 84 acres (15 acres in this sub-watershed may be treated by SM-22)

Concept: This existing wet pond in College Gardens Park would be expanded to treat runoff diverted from a large storm drain pipe in the park. A wetland marsh fringe (2-12" deep) would be planted around the edges, and would have deeper water of 4 feet deep at the upper end near the ball field and 6.5 feet in the center of the main pool. A peninsula separating the forebay and the main pool would add visual interest. The expanded pond would encompass the sand volleyball court and pavilion; both of these could be relocated to another location in this park. The concept calls for saving most of the trees on the existing dam and many large trees near College Parkway. A concrete control structure and outfall pipe would be added to replace the deteriorating riser that returns drainage to the storm drain system. This project is the only one in the watershed study which is an existing pond, but is not currently a SWM pond; the consultants therefore classified it with an 'SM-' designation to reflect that it would be a modification of an existing pond site. The 'SM-' designation does not imply that a site is necessarily serving as a current SWM facility.

Advantages: achieves substantial SWM control for subwatershed; can add ornamental features to design and setting; maintains similar depth and permanent water surface area of existing pond; educational opportunity for adjacent College Gardens E.S. schoolchildren and summer Recreation Dept. programs

Disadvantages: disturbs heavily used park; requires relocation of pavilion and volleyball court; reduces grassed area for active and passive recreation; clears about 30 trees bigger than 8" diameter; clearing may be visible from 15 houses

Alternatives Considered In Study:

Staff met numerous times with the College Gardens Civic Association to discuss alternatives to this proposal. The civic association formed a subcommittee to comment separately from the Watts Branch Partnership on the two SWM alternatives proposed for this neighborhood. The initial comments received from the civic association are included in the appendices. To preserve the park's open space, the civic association asked the City to consider several alternatives, which were investigated by DPW staff and the Center.

Staff assessed burial of the proposed pond forebay in an underground concrete vault to keep the upper area of the pond in grass instead of a wet pool. Based on the forebay's projected volume, this vault would cost roughly $224,000 for concrete alone, compared to about $3,000 in excavation costs for a surface forebay. The vault would also need manholes or access doors for cleanouts and inspections. If this vault was placed within either the park or the adjacent ballfield, the access structures would make the grassed area unsafe for active recreation. Additionally, multiple underground water quality structures throughout the storm drain network were considered and cost estimates developed. This would be extremely expensive, much more of a maintenance burden and less effective in pollutant removal than wet pond treatment. Staff therefore recommends against these alternatives.

Staff also explored using the stream valley downstream of Princeton Place for SWM in lieu of College Gardens Park. The storm drain through College Gardens Park empties into a wooded stream channel behind houses on the north side of College Parkway. Early in the SWM Inventory, this alternate site (SD23) was investigated by the Center and rejected because of the increased drainage area, the need for an in-stream dam, steep wooded slopes on one side, and nearby houses along College Parkway. The drainage area increases from 84 acres in College Gardens Park pond to roughly 120 acres at the storm drain outfall.

After revisiting the site during the Open House period, staff and the Center still found this site problematic, even for a pond to control only part of the drainage area. Because of the houses' flat backyards, the dam would not only block the stream but wrap around the side to form a levee between the pond and the houses, which would increase dam safety hazards. The City Forester also recommended against this alternative because of the significant forest clearing needed to excavate the storage basin below the inflow culvert's invert. Finally, federal and state wetland regulators informed staff that this location would not be permittable if an alternative exists which has no wetland impacts. As a result, this location was rejected by City staff as impractical.

Another suggestion was to build a single large dry pond on this tributary closer to the mainstem. This would avoid the dam safety issues for the houses along College Parkway, but would increase the drainage area even more, resulting in a much larger pond, and move the disturbance deeper into the woods and further down the stream channel

A field meeting was held in August, 2001, between City staff, the College Gardens Civic Association (CGCA) and the Army Corps of Engineers and Maryland Department of Environment to get further direction from the state and federal regulators on the feasibility of obtaining wetland/waterway permits for an in-stream pond or ponds in the College Gardens tributary. The Corps of Engineers representative stated that an in-stream pond anywhere along the tributary downstream of Princeton Place is not a permittable option because there are practicable alternatives outside of the stream valley. The Maryland Department of the Environment representative concurred, stating that on-line or off-line SWM facilities in this tributary would create unnecessary natural resource impacts. Both regulatory agencies advised against further consideration of on-line or off-line SWM facilities along this tributary.

The Center prepared several alternative concepts for the proposed pond and analyzed costs, footprint size, and treatment capabilities. This work will be expanded in the future alternatives analysis discussed below.

Recommendations:

The changes proposed for College Gardens Park are of great concern to the residents. The project was discussed extensively in meetings with the Partnership members, other representatives of the College Gardens Civic Association and interested residents. The community asked that the City consider alternatives before committing to expanding the park pond, and the Mayor and Council agreed to this at the adoption of the watershed management plan.

Therefore, the City will have an engineering consultant team prepare an alternatives analysis for SWM options in the College Gardens sub-watershed, including evaluation of feasible options that might reduce the proposed pond's footprint in the park. After the CIP project funding for the College Gardens Park project is appropriated, the consultant will begin the alternatives analysis as the first step in the design for College Gardens SWM. This will allow a single design team to evaluate the options and comments from the community, staff and Mayor and Council before proceeding with final design of whatever alternative is chosen, resulting in greater continuity and efficiency for the project.

After initial data gathering, the City and the consultant will meet with interested people from the community, including representatives from College Gardens Civic Association and Montgomery County Public Schools (MCPS), to discuss concerns and explore options. The goal of the alternatives analysis will be to determine which watershed improvements provide the best balance between natural resource protection, park usage and safety concerns, community concerns, aesthetics, cost, and watershed protection for the College Gardens tributary. The consultant shall use available information from the Watts Branch Watershed Study and will provide additional engineering concept analysis of feasible proposals, as needed. It will be important for the City and the community to articulate realistic objectives early in the process.

The consultant's findings and recommendations will be circulated and discussed with those who have expressed interest or attended the initial meetings. After further discussion with the public, staff will present the benefits and constraints of each alternative, a summary of outstanding issues and recommendations to the Mayor and Council for their decision. DPW will then proceed with final design of the Mayor and Council's chosen alternative.

The consultant design team shall include a parks designer to address layout and safety issues in College Gardens Park. This site will need special coordination with the Department of Recreation and Parks (R&P) and the community since it is a heavily used park. The City Forester's request to move the pond's limit of disturbance further northward (to help preserve existing trees around the current dam) should be considered in the design stage. This will have to be balanced against community desires to maintain open space at the north end of the pond. R&P also has final authority over selection and design of any amenities or recreation opportunities in the park.

The design team will also coordinate with MCPS on park layout and obtain available plans for the College Gardens Elementary School expansion to use in the alternatives analysis and any final design within the park. The alternatives analysis and final design should address the following:

- Flexibility in SWM design, layout and size to help resolve residents' concerns while still meeting the watershed goals;
- SWM design details should promote safety, attractiveness and softening of the manmade structures visible in the ponds;
- Opportunities to reduce the SWM pond footprint will be explored;
- The park will be considered as a whole.

The proposed pond will necessitate relocation of the existing sand volleyball court and pavilion at the park. A non-regulation size sand court could be placed between College Parkway and the basketball court, if desired by the community, and the gazebo moved closer to the existing storage building. Currently, the Recreation Division uses College Gardens Park for a playground program in the summer, and believes that the pond will be compatible with programmed uses. The Recreation Division has asked that a pedestrian bridge spanning the forebay weir be included to improve circulation within the park. College Gardens Elementary School is slated for modernization by Montgomery County Public Schools (MCPS) in upcoming years. The modernization is expected to add a gym by taking ballfield area near the school. The City and MCPS expect that the active ballfield closest to College Garden Park will remain available for community and Recreation use.

The forebay, in particular, has been a source of concern for the community. The forebay provides the benefits of containing trash and sediment in one place within the pond, thus keeping the rest of the pond more attractive, and of creating a more irregular, pleasing shape to the pond's footprint. However, the forebay will take up open grassed area and the existing sand court. Staff and the consultants will re-examine the pond layout at the alternatives analysis stage to consider whether the pond could function adequately and be an attractive amenity without the forebay. Staff will evaluate all practical options, such as new cost-effective SWM technology, a different pond shape, a deeper pond, or using the College Gardens Office Park (SM-22) pond retrofit as a substitute for the College Gardens Park pond forebay.

The wooded condition of the existing pond's dam will need to be addressed in the design. Current dam safety requirements call for dams to be kept cleared of all trees and shrubs. Some members of the College Gardens Civic Association have requested that an expansion of the College Gardens Park pond move the dam southwest into the existing tot lot area, rather than preserving the dam and expanding the pond northeast into the play area around the sand court. However, the established trees around the dam are a valued feature to many other residents who have requested that the trees be preserved if at all possible. At the design stage, discussions should be held early in the process with the dam regulatory agency, the Natural Resources Conservation Service, to determine an acceptable redesign.

One option is to construct a new embankment with a full core trench upstream of the existing one. This might allow the trees on the older part of the dam to be safely retained if the new embankment has its own structural integrity. A bio-barrier or other impervious membrane would be introduced between the embankments to prevent root penetration of the new dam. The pond may need to be designed to maintain a Class 'A' dam rating to minimize dam breach hazards downstream. Also, the 100-year flood should be routed around the new pond to reduce unnecessary flows through the pond. The final landscaping plan should consider elements to improve the dam's appearance, such as ornamental plantings acceptable to the dam safety agency, boulders and more irregular grading of the top of the dam.

The proposed pond will be subject to federal and state permits from the regulatory agencies since it joins "Waters of the United States". The agencies have indicated that they will support the proposed College Gardens Park concept.
ID: SM-24
Name: Montgomery College Pond
Type: Wet Pond
Drainage Area = 123 acres

Concept: This existing wet pond, located on the Rockville Campus of Montgomery College next to Campus Drive West, would have minor modifications to the control structure to provide more effective release rates, although storage volume is very limited for both quality and quantity due to elevations of surrounding roads. Wetland plantings and/or an aerator or fountain would help improve water quality and pond appearance.

Advantages: simple, low-cost retrofit; no change to pond appearance or setting

Disadvantages: Private pond; only achieves 20% of necessary SWM control due to limited space

Recommendation: At this time, the City does not anticipate funding this private pond retrofit. However, the City will work with the college to facilitate this project. The College's Property Manager has expressed willingness to follow through on the retrofit. It should be noted that the downstream improvements will be marginal, given the limited effectiveness of this undersized pond. Some College Gardens Civic Association members felt strongly that any feasible SWM improvements in the college's pond should be achieved since the receiving tributary is important to their community.

ID: SD-6
Name: Woottons Mill Park
Type: Dry Pond with Micropool
Drainage Area = 38 acres

Concept: A new pond with two permanent pools would be added opposite Feather Rock Drive between the basketball court and the tot lot along a wooded, intermittent stream. The plan calls for a 4 foot deep forebay at the outfall of the existing storm drain from Hurley Avenue and a 3 foot deep micropool closer to the proposed dam. Both pools would be in the stream channel. This project would require clearing and regrading to create the area needed for temporary ponding, although the side slopes of the pond and the area between the forebay and micropool would be reforested.

Advantages: stabilizes the eroded stream channel at the site; achieves full water quality and partial water quantity control

Disadvantages: clears about 0.65 acres of forest; possible relocation of recreation facilities; limited value to downstream erosion protection; clearing may be visible from 4 houses

Recommendation: R&P recommended that this project be dropped because of the good condition of the drainage swale below the pond site. Currently, the channel where this pond would be sited has minor-moderate erosion between Hurley Avenue and the edge of the woods. Below this, the channel ends in a wetland area of reed canary grass; runoff flows through the grass about feet until it reaches the mainstem of Watts Branch. Since this grassed area is not currently experiencing erosion, the channel protection component of the SWM pond does not appear necessary at this time.

The pond would aid by providing water quality treatment for 38 acres of residential runoff. DPW recommends that the project remain in the management plan, but receive a low priority for implementation. If conditions change in the overbank area at Woottons Mill Park, or if the existing channel below the outfall continues to downcut, the pond may be needed to avoid erosion from this drainage area.

ID: SD-8
Name: Glenora Park
Type: Wet Pond
Drainage Area = 174 acres

(Total Drainage Area = 207 acres, including 33 acres treated through the Fallsgrove development)

Concept: This new pond is sited in the open space in Glenora Park opposite Glenora Lane and Balmoral Drive. Three large storm drains outfall into the head of the stream through the park. The concept calls for a permanent wet pond of up to 5 feet deep on the stream channel and extending east by excavating the adjacent grass field. The new dam would cross the stream at the existing pedestrian bridge and run parallel to the current tree line. The side slopes of the pond could be replanted with grass, shrubs or trees, although no trees are allowed on the dam. A tot lot next to the stream was replaced by R&P in Fall, 2000. If the SWM project is approved, the tot lot would be relocated to another site in Glenora Park, such as near the tennis courts, for safety reasons and to protect the tot lot from frequent flooding. For cost effectiveness, pond construction should coincide with the next projected replacement of the tot lot in ten years.

Advantages: achieves full water quantity and substantial water quality control; provides good erosion protection to severely eroded channels immediately downstream; avoids most of the adjacent stream valley forest in the park

Disadvantages: replaces large grass play area and requires relocation of nearby tot lot; clears about 0.3 acres of forest; clearing may be visible from 5 houses; requires relocation of a sewer line

Recommendations:

The Glenora Park pond is a key project for the Watts Branch management plan, both because of the relatively large drainage area it will control, and because it is needed to combat severe erosion downstream. The timing of this project must be coordinated closely with R&P and with local residents. Stream restoration ideally should be done concurrently or after upstream SWM controls are installed. The SWM allows less intrusive restoration techniques to be used, and helps protect the stabilization while the bank plantings take root. Currently, the Carter Hill Homeowners' Association's swimming pool property is threatened by erosion from the stream below Glenora Park. Although R&P has recommended that the pond be delayed until the onsite tot lot needs to be replaced, spot erosion problems downstream may need to be addressed earlier. Staff will continue to work with the Carter Hill HOA to help them obtain grants or other aid to deal with the erosion on their privately owned stream segment.

During the study, staff received limited input from local residents regarding this project; most of the concerns expressed related to safety and recreation availability for neighborhood children. Although this site is not used for programmed activities by R&P, it is heavily used by the neighborhood for informal recreation. The Glenora Park Civic Association was not represented at Partnership meetings, but several residents spoke at the Mayor and Council's Public Forum against the Glenora Park SWM project. They are concerned about loss of play area near Dundee Road, safety issues and appearance.

At the design stage, staff will work with the community and R&P to identify alternate recreation opportunities, such as an acceptable site within the park for the relocated tot lot. R&P has suggested that Glenora Park is fairly large and that the remaining space, including the ballfield, be considered for regaining the passive recreational space, if necessary. The Director of Recreation and Parks compared this site to the Potomac Woods Park ballfield/SWM project, which adjusted the park layout to meet several goals. Landscaping choices should also be discussed with nearby residents.

This project will require state/federal permits. The wetland/waterway regulatory agencies suggest that the City re-align the outfall, if possible, to discharge into an offline swale before entering the stream channel. However, the extensive stream stabilization in this reach may make an in-stream outfall more appropriate since overbank area is limited at this point. The permitting agencies also asked that the City investigate maintaining a small baseflow in the section of abandoned stream channel between the dam and the pond outfall. This suggestion may be dropped by the agencies if little or no aquatic life is found within the upper stream reach; the abandoned channel is expected to revert to wetlands in either case.

ID: SD-12
Name: I-270 Interchange
Type: Dry Pond with Micropool
Drainage Area = 26 acres

Concept: This existing dry pond, located on State Highway Administration property between southbound I-270, eastbound Rte. 28 and the southbound I-270 on-ramp, would be modified to regrade the bottom of the pond to redirect flow through the established shallow marsh and change the control structure to provide the appropriate release rates. A trash rack would also be added to the riser.

Advantages: achieves full SWM control; simple, low-cost retrofit; no natural resources impacts

Disadvantages: none

Recommendations: This project is on Maryland State Highway Administration (MSHA) property, and will require consent & coordination through MSHA. A copy of the concept plan and computations was forwarded to MSHA in Fall, 2000, for review and comment, and a field meeting was held with MSHA representatives in Spring, 2001. City staff should work with MSHA to facilitate this project. Preliminary discussions with MSHA indicated that it would be low on MSHA's SWM retrofit priority list due to its size and the good condition of the existing riser. The City does not anticipate funding this project, but MSHA may have funding available through its SWM improvement program, or the City may obtain outside grant funding to implement it independantly. MSHA expressed willingness to grant permission for the retrofit if it was constructed by the City.

ID: SD-16
Name: Nelson Street
Type: Dry Pond with Micropool
Drainage Area = 37 acres
WITHDRAWN FROM FURTHER CONSIDERATION

A new pond was proposed for the State Highway Administration property between Nelson Street and I-270 opposite Beall Avenue. A dry pond with a small permanent pool would receive drainage from the existing storm drain outfall from Nelson Street. The pond was constrained by a water line and the mainstem of Watts Branch directly to the north and only 270 feet between Nelson Street and I-270. Since the pond could not be configured to fit the site without substantial forest clearing which would expose I-270 to the residents along Nelson Street, it would increase noise levels at the houses by about 10 decibels and also greatly alter the residents' views. A noise wall along the highway would mitigate the effects, but there was no way to guarantee this could be provided. Because this project would have such great disadvantages to nearby residents, the City staff, in consultation with the Partnership and the West End Civic Association, withdrew it from further consideration.

ID: SD-22
Name: Fordham Street
Type: Shallow Marsh
Drainage Area = 31 acres

WITHDRAWN FROM FURTHER CONSIDERATION

Concept: This new wetland marsh pond, located northwest of the intersection of Fordham Street and Princeton Place, is proposed on a wooded portion of Upper Watts Branch Park. The pond would be offline, fed by diverting frequent storms from the existing storm drain pipe which discharges into Watts Branch next to this site. A forebay of up to 3 feet deep and a micropool of 4 feet deep would be part of the permanent pool which will consist mostly of shallower (2-12" deep) water with aquatic plants and shrubs. Two small peninsulas are proposed to increase the flow length and add room for vegetation. Trees would be replanted on the eastern embankment, and the dam next to the existing trail and sewer line would be planted with grass or ground cover.

Advantages: expansion of existing wetlands and improved habitat; achieves full SWM control; would be partially surrounded by existing forest

Disadvantages: clears about 0.65 acres of forest; clearing may be visible from 7-9 houses; disturbs small area of existing wetland

Recommendations: This project was modified after discussions with an adjacent resident to move the limit of disturbance 50 feet away from the park's southern property line, thus leaving the existing storm drain and sewer rights-of-way undisturbed. The maintenance access path was also moved away from this residence. Notification for this project should include residents across the stream valley on Wintergreen Terrace.

This project would require state/federal wetland permits. The wetland/waterway regulatory agencies decided that, given the extensive springs in the pond area, this project is not permittable under current standards as designed. They recommended that the City investigate changing this into a small outfall treatment area for water quality only, and allow the majority of the runoff to stay in the existing storm drain pipe. A possible redesign was investigated to flow-split only the first flush into the existing wetlands, and create a 12-18" berm around them using coir fiber logs staked into place to avoid grading. A rip-rap outfall would conduct the overflow into the existing side tributary.

Since the new State SWM Manual prohibits release of untreated runoff to natural wetlands, the City would need a large manufactured water quality inlet at the flow-splitter for pre-treatment. This design was also rejected by MDE because it would change the hydrology conditions of the wetland and therefore staff withdrew the Fordham Street site from further consideration at this time.

ID: SD-24
Name: Calvert Road
Type: Dry Pond with Micropool
Drainage Area = 66 acres
(Total Drainage Area = 100 acres, including 24 acres treated through Rose Hill development)
WITHDRAWN FROM FURTHER CONSIDERATION

Concept: A new online SWM dry pond with two permanent pools separated by trees was proposed through a wooded area between Bullards Park and the Rockville Christian Church. The lower part of the pond would be graded to provide a 3 foot deep micropool and a dam that would be planted with grass or ground cover. Undisturbed woods would remain in the center of the pond, where temporary ponding would be held for up to 24 hours after storms. A small, 3 foot deep forebay would be located at the end of the existing 48” storm drain pipe at the head of the stream which flows through this area. The majority of this project is located on private land owned by the church, although a portion of the forebay would be on City-owned land. An access path would be cleared through both city and church property along the City’s existing sanitary sewer line for construction and maintenance.

Advantages: stabilizes an eroded stream at the site; achieves full SWM control for the intended 66 acre drainage area

Disadvantages: mostly on private site – requires permission from church; clears about 0.8 acres of forest; clearing may be visible from 4 houses; Roxboro residents strongly opposed to any further tree clearing in vicinity, especially on City park land.

Recommendations: The Rockville Christian Church sent a letter on November 14, 2000, stating that the Church Board rejected committing its land for this project. Since the church was not able to grant permission at this time, the City withdrew this concept from further consideration due to lack of available land to carry out the project.

ID: O-3
Name: Welsh Park
Type: Dry Extended Detention with Micropool and Forebay
Drainage Area = 53 acres

Concept: This new pond would be sited in a wooded stream valley area upstream of the pedestrian path between Welsh Park's ball field and Beall Elementary School, northeast of Lynch Street. A micropool of up to 4 feet in depth would follow the existing eroded stream channel parallel to the path. A small, 3 foot deep forebay would be placed directly upstream. The existing embankment of the path would be raised 1 to 5 feet to provide the dam for the pond. A wetland area, consisting of an existing spring and its outflow channel, next to Beall Elementary School would remain undisturbed, and would drain directly into the pond's control structure.

Advantages: existing wetlands, pedestrian path and other recreational features would remain at Welsh Park; achieves full SWM control; adds wetland habitat to site; educational opportunity for adjacent Beall Elementary School schoolchildren and summer Recreation Services programs

Disadvantages: clears about 0.75 acres of forest; clearing may be visible to 3 houses; existing sanitary sewer must be relocated around edge of pond's permanent pool.

Recommendation:

This project was the subject of many inquiries during the summer Open House period. After gaining an understanding of the project, most people commented favorably and felt this pond would fit in with the character of the park. Frequently expressed concerns included a need for increased trash removal, maintenance of the existing paved path across the dam, and preserving the existing benches around the spring behind Beall Elementary School. The SWM project will be able to accommodate all of these issues. The Department of Recreation and Parks may also wish to locate a trash receptacle along this path since trash is an ongoing problem in this location, according to residents.

The Center performed a limited dam breach analysis to check that downstream houses would not be flooded in the event of a dam failure. The stream enters a 42" storm drain pipe just below the dam, and this pipe was determined to be adequate to handle a dam failure flood without inundating the houses. However, a nearby resident mentioned that the stream has occasionally overflowed into Lynch Street. Based on observations of current topography, today's overflow conditions may lead into Lynch Street rather than staying in the channel downstream of the existing pedestrian path. In the final design stage, after detailed topographic information is obtained, the consultant should perform a more detailed dam breach analysis and determine the flowpath. Some regrading and extension of the dam may alleviate this situation.

Beall Elementary School was also contacted about this project; the school staff's primary concern is for children's safety. In addition to standard safety features for this wetland marsh, staff should discuss the need for a fence with the school during the final design stage. The school may also wish to use the wetland marsh in educational programs or lessons.

This will require state/federal permits. The regulatory agencies recommended that the City redesign the pond to avoid the existing wetland; this revision was made and resulting in changing the concept from a shallow marsh system to a dry extended detention pond to achieve water quality treatment. The Army Corps of Engineers representative considers this revision to be approvable.

Table 3.6 Stormwater Management Concepts Summary Data

SWM Facility	Type of SWM Facility	Drainage Area (acres)	% Capture of Channel Protection Volume	% Capture of Water Quality Volume	Permanent Water Depth (Feet)	Temporary Water Depth (Feet) for 1-year storm	Surface Area at Top of Dam (acres)	Tree Loss (Acres) or Significant Trees (>8") Loss
Carnation Dr. – SM20	Dry pond w/ micropool & forebays	358	98%	37%	3'	10.1'	2.2	1.04
270 Industrial – SM18	Dry pond w/ micropool & forebay	322	95%	65%	3.5'	9.3'	2.3	1.06
College Gardens Park Pond – SM23	Wet pond w/ fringe marsh	84 (designed for 84 acres; 15 acres goes to SM22)	92%	70%	6.5'	12.6'	1.1	37 trees >8"
Welsh Park – O-3	Dry pond w/ micropool & forebay	53	100%	93%	4'	7'	0.83	1.1
Horizon Hills #1 – SM3 (upstream one)	Dry pond w/ fringe marsh micropool & forebays	88	100%	100%	4'	11.3'	1.0	15 trees >8"
Horizon Hills #2 – SM2 (middle one)	Dry pond w/ fringe marsh micropool & forebay	105 total (27 acres more than SM3)	100%	100%	4'	8.7'	1.5	6 trees >8"
Horizon Hills #3 – SM1 (downstream one)	Dry pond w/ fringe marsh micropool & forebay	185 total (80 acres more than SM2)	100%	100%	4'	9.2'	1.8	9 trees >8"
Woottons Mill – SD6	Dry pond w/ micropool & forebay	38	44%	100%	3'	7.1'	0.32	~0.65
Glenora Park – SD8	Wet pond w/ fringe marsh	207 (174 acres uncontrolled)	100%	80%	5'	13'	0.75	0.3 acres/20 trees >8"
Lakewood Country Club – SM9	Wet pond	46	100%	100%	5.5'	6.5	1.2	None
PEPCO Sevice Center Site – SM19	Dry pond w/ micropool & forebay	19	95%	76%	3'	7.6'	2.2	Not available

 August 2001

SWM Facility	Type of SWM Facility	Drainage Area (acres)	% Capture of Channel Protection Volume	% Capture of Water Quality Volume	Permanent Water Depth (Feet)	Temporary Water Depth (Feet) for 1-year storm	Surface Area at Top of Dam (acres)	Tree Loss (Acres) or Significant Trees (>8”) Loss
College Gardens Office Park – SM22	Wet pond	15	100%	100%	4.7’	7.5’	0.84	None
Montgomery College Pond – SM24	Wet pond	123	30%	20%	5.7	8.5	1.5	None
I-270 Interchange – SD12	Dry pond w/ micropool & forebays	26	100%	100%	Not available	Not available	0.4	Not available

Detailed concept design drawings of the 18 sites were prepared as part of the Phase II tasks. The plans and supporting calculations contained information such as plan and profile of proposed retrofit, control structure and pipe sizes, limits of disturbance, construction and maintenance access, utility protection/relocation (if necessary), impacts to natural resources, dam breach potential (where applicable), and an estimate of number of trees to be removed. The design information was presented to the Watts Branch Partnership at several meetings and displayed at the two open houses by the City. Due to the size of the plans, they are not included in this report; however, the City maintains copies of the relevant information[2].

As noted above, after presenting and discussing the 18 candidate retrofit site concept designs, three of the sites were ultimately dropped from consideration due to objections from regulatory agencies, the public or other logistical problems (e.g., property ownership, permitting constraints). The three sites that were removed from further consideration included SD-24 (Calvert Street), SD-22 (Fordham Street), and SD-16 (Nelson Street). In addition, one site, SM-8 (Aintree Pond), is being improved at this time outside the watershed study process. This results in 14 sites as priority implementation projects for the watershed study.

The retrofit ranking system is one of two elements that was used to make decisions about which potential retrofit projects should be investigated further within the overall watershed management plan. The second element evaluates the highest scoring sites on a subwatershed basis to help define the specific subwatersheds of Watts Branch that should be the priority for implementation. This is effectively a watershed management ranking approach which is more subjective in nature but reflects the real world issues associated with getting projects approved and constructed in a cost effective manner. This ranking process requires consideration of factors such as which projects will be the least disruptive to the public, which projects can work within the constraints of the capital improvement projects budget, and which projects can be linked together to provide design and construction economies of scale. This important project management ranking element is described in Section 5, where retrofit recommendations are outlined for consideration in the final watershed management plan for Watts Branch.

3.6 Hydrologic Modeling Assessment of Priority Retrofit Sites

As previously described in Section 2.3, a hydrologic analysis using the NRCS model, TR-20 was conducted to assess the effect that the proposed priority stormwater retrofits will have on the peak discharges at several design points in the watershed. Figure 3.2 shows the priority retrofit sites with their associated contributing drainage areas. The assessment was performed considering both existing and ultimate build-out conditions in the watershed.

Existing Development Condition with Existing and Proposed Structures
With this model run, it will be able to assess the effectiveness of proposed structures on the stream system, when compared to previous model runs (Section 2.3). Table 3.7 shows the peak discharges

[2]There are several pieces of project support information that have not been included in this Watershed Study document, but are still part of the project record maintained by the City. Appendix F provides a list of such information.

for each of the ten historic cross sections and at other selected locations within the watershed.

Table 3.7 Peak Discharges – Existing Condition with Existing and Proposed Structures

Return Period	**6 Month**	**1 Yr**	**18 Month**	**2 Yr**	**10 Yr**	**100 Yr**	
24 Hour Rainfall	**1.7”**	**2.6”**	**3.0”**	**3.2”**	**5.1”**	**7.2”**	
Location	**Qp-cfs**	**Qp-cfs**	**Qp-cfs**	**Qp-cfs**	**Qp-cfs**	**Qp-cfs**	**TR-20 Reference (Area Sq. Mi.)**
Cross Section 1	6.40	19.44	44.34	76.99	593.69	1163.21	Struct 2 Resvor (.54)
Cross Section 2	12.37	41.75	78.25	99.15	304.49	506.89	Struct 7 Addhyd (.26)
Cross Section 3	18.60	66.26	97.96	147.28	1035.36	1790.33	Struct 6 Addhyd (1.32)
Cross Section 4 & 5	102.63	350.34	476.92	544.45	1164.39	2039.36	Struct 14 Addhyd (2.40)
Cross Section 6	118.01	389.02	487.30	550.49	1158.14	1984.44	Struct 17 Resvor (2.50)
MD Route 28	90.66	348.35	458.43	516.83	1147.46	1855.92	Struct 18 Resvor (2.50)
Cross Section 7 & 8	96.53	338.67	514.33	629.28	1865.30	3410.29	Struct 32 Addhyd (3.82)
Hurley Avenue	2.07	14.06	31.81	45.26	238.94	448.31	Struct 39 Resvor (0.32)
Cross Section 9	102.86	370.39	550.43	689.63	2204.02	4003.19	Struct 43 Addhyd (4.43)
Cross Section 10	103.46	372.85	552.60	691.75	2211.15	4010.66	Struct 43 Addhyd (4.45)
City Boundary	132.46	462.45	690.95	794.5	2354.04	4216.63	Struct 70 Addhyd (6.46)

Ultimate Development Condition with Existing and Proposed Structures

Table 3.8 shows the peak existing development discharges for each of the ten historic cross sections and at other selected locations within the watershed.

Table 3.8 Peak Discharges – Ultimate Condition with Existing and Proposed Structures

Return Period	**6 Month**	**1 Yr**	**18 Month**	**2 Yr**	**10 Yr**	**100 Yr**	
24 Hour Rainfall	**1.7”**	**2.6”**	**3.0”**	**3.2”**	**5.1”**	**7.2”**	
Location	**Qp-cfs**	**Qp-cfs**	**Qp-cfs**	**Qp-cfs**	**Qp-cfs**	**Qp-cfs**	**TR-20 Reference (Area Sq. Mi.)**
Cross Section 1	9.09	80.79	188.63	261.30	741.30	1325.89	Struct 2 Resvor (.55)
Cross Section 2	43.10	129.37	175.92	200.15	402.49	610.37	Struct 6 Runoff (.25)
Cross Section 3	29.31	121.15	264.83	362.78	1199.80	1915.56	Struct 6 Addhyd (1.33)
Cross Section 4 & 5	139.95	400.51	543.33	618.16	1323.38	2157.80	Struct 14 Addhyd (2.41)
Cross Section 6	153.16	422.33	542.08	613.41	1333.61	2073.07	Struct 17 Resvor (2.52)
MD Route 28	120.06	395.76	514.94	579.39	1317.37	1988.57	Struct 18 Resvor (2.52)
Cross Section 7 & 8	223.47	659.78	897.87	1022.87	2295.75	3767.39	Struct 32 Addhyd (3.83)
Hurley Avenue	2.94	17.04	38.95	54.10	285.46	519.12	Struct 39 Resvor (0.32)
Cross Section 9	229.81	683.48	939.81	1088.32	2650.13	4288.30	Struct 43 Addhyd (4.45)
Cross Section 10	230.40	685.16	942.29	1091.28	2657.27	4295.80	Struct 43 Addhyd (4.47)
City Boundary	242.96	713.20	981.88	1123.57	2778.47	4479.06	Struct 70 Addhyd (6.46)

Figure 3.2 Priority Retrofit Sites with Associated Drainage Areas

SECTION 4. STREAM, WETLAND, AND FOREST REHABILITATION OPPORTUNITIES

This section describes rehabilitation opportunities associated with the stream valley and riparian corridor of Watts Branch and its tributaries. The primary focus of the rehabilitation discussion is on opportunities for stream rehabilitation and stabilization to improve habitat and reduce channel erosion. Concept designs for specific reaches were developed as part of the Phase II work and are described below. In addition, reforestation and wetland management plans were developed to supplement and enhance the existing forest and wetland resources within the Watts Branch riparian corridor.

4.1 Stream Rehabilitation Opportunities

A total of 62 stream reach locations were identified as being in need of stabilization or rehabilitation, as part of the RSAT assessment (see Figure 4.1). Where appropriate, adjacent locations were combined to form a single rehabilitation site. Using this approach, 35 stream reach rehabilitation sites were identified. This section presents an inventory and describes the ranking system used to document which stream rehabilitation projects have the highest priority for implementation. Lastly, this section presents the list of the highest priority sites.

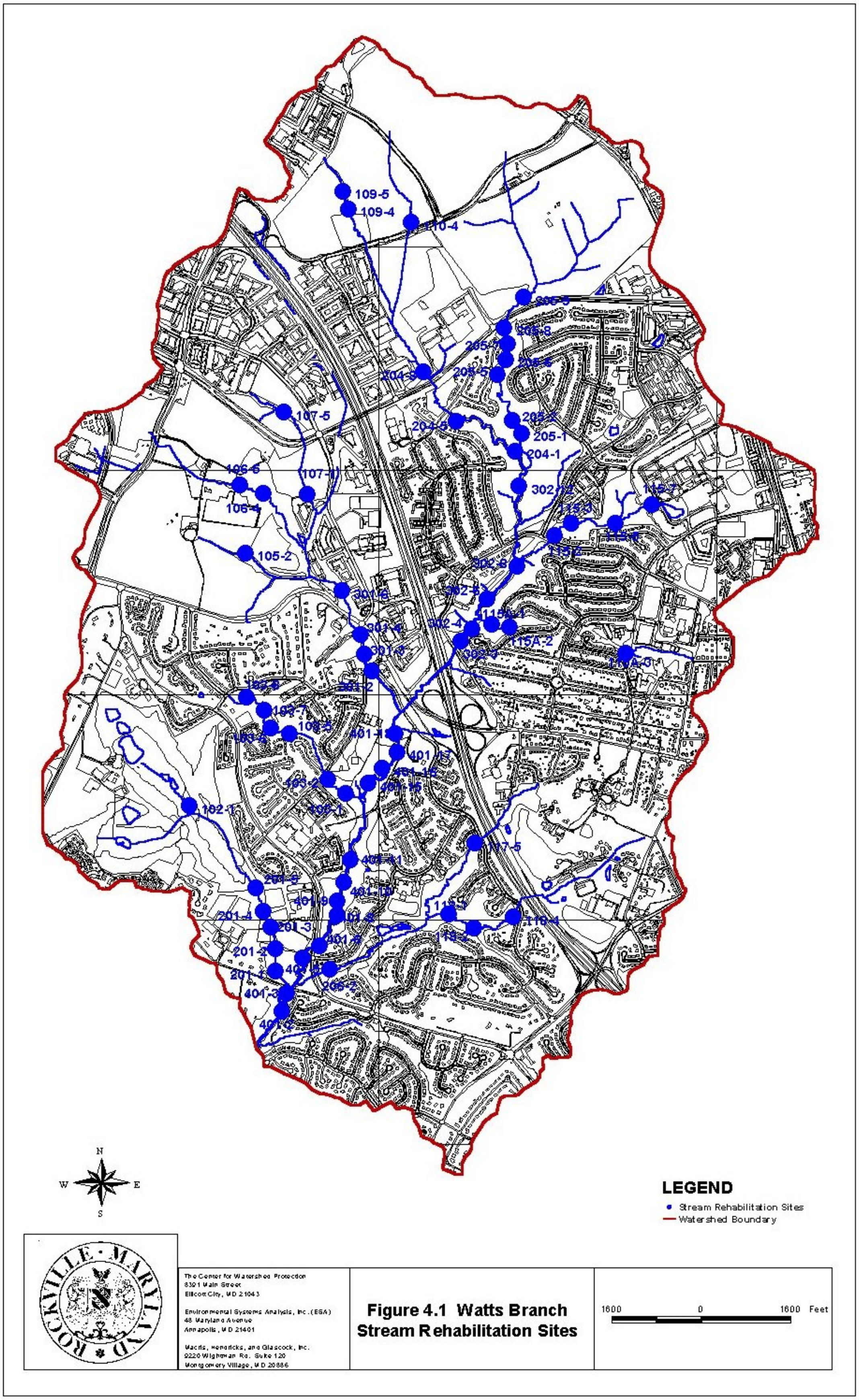
Stream rehabilitation involves the recovery of eco-system functions and processes in a disturbed habitat. Rehabilitation, however, does not necessarily reestablish the predisturbance condition, but does involve establishing hydrologically stable landscapes that support the natural ecosystem mosaic (USDA, 1998). Stream rehabilitation can cover a broad range of practices including riparian reforestation, wetland creation and enhancement, habitat creation, and streambank stabilization. For this phase of the Watts Branch study, the stream rehabilitation focus is primarily on opportunities for streambank stabilization using both "hard" or structural practices and bioengineering practices (practices that employ live vegetation). Wetland enhancement and forest conservation recommendations were also developed, but in less detail than the stream rehabilitation concepts.

There are a suite of streambank stabilization measures that can be implemented depending on the site-specific characteristics. Practices that have been recommended as part of this study include bioengineering, imbricated riprap, boulder revetment, root wads, and bank shaping. A brief description of these practices is provided below:

Bioengineering–practices that involve the use of plant material in the form of live woody cuttings or poles of readily sprouting species (e.g., willows), which are inserted deep into the bank or anchored in various other ways (USDA, 1998). Bioengineering is a more flexible technique that allows the stream channel to adjust to the hydrologic and sediment regime of the stream.

Boulder revetment–structural practice comprised of placed boulders at the toe of banks to provide protection against undercutting that may result in bank failure. This practice is usually combined with other practices that address stabilization or protection of the upper bank.

Figure 4.1 Watts Branch Stream Restoration Sites



Imbricated riprap–structural practice comprised of placed rock (usually large and flat) that is rigid and robust to protect the entire vertical extent of the stream bank from erosion or potential failure. Imbricated riprap is often utilized in areas where eroding banks threaten private property or infrastructure and there is little space available for stream bank re-grading and the use of bioengineering techniques or where these techniques would not provide a sufficient level of protection.

Root wads–practice using large logs with intact roots that are placed in trenches cut into the banks so that the root wads face upstream to dissipate flow velocities. These bank protection measures are rigid, however, they also provide dynamic near-bank habitat (USDA, 1998).

Bank shaping–practice that involves re-grading the stream bank to a stable angle and geometry and the utilization of vegetative plantings to stabilize the stream bank and prevent future bank erosion.

4.1.1 Description of Stream Rehabilitation Inventory

A stream rehabilitation inventory was incorporated into the RSAT field study to identify reaches of stream that show signs of degradation and instability. The RSAT assessment identified all significant erosion areas within the limits of the investigation. It is important to note that not all stream channels were field investigated due to the limitations of the RSAT technique as described in Section 2.2.2. Consequently, some erosion areas may exist on non-RSAT stream reaches.

The Stream Rehabilitation Inventory also reflected a certain amount of judgement on the part of the consultants, who walked and took observations along the entire length of every stream. Streams are not homogenous, and conditions can change from stable to eroded over a short distance. Therefore, stream rehabilitation sites were selected based on average conditions in a stream reach. Since streams are dynamic systems, responding to both natural and man-made influences, no single rating system or series of measurements can categorize a stream as stable or unstable in the absence of professional judgment.

“Best professional judgment” of the severity of erosion is based on several criteria including bank height, bank slope, bank material, erosion pattern, and presence or absence of roots/riparian vegetation. Conditions were compared relative to each stream, as well as to urban streams in general. The RSAT scoring system was used at riffles located approximately 400 feet apart, and tends to represent conditions at and immediately adjacent to the RSAT point. RSAT score for channel stability was considered, but there was no “cut-off” score to determine inclusion on the rehabilitation list.

There are more detailed and measurable methods to evaluate stream erosion and to select sites in need of stabilization, including bank pins and scour chains to detect bank and bed erosion, respectively, and the establishment and monitoring of permanent cross-sections to determine any and all changes in cross-sectional geometry. Typically, several years of data (5 or more years) are required for these methods to document changes caused by erosion. Due to the amount of effort required, they are only used over long periods, typically for individual reaches as part of a research effort. In the future, the City expects to use the geomorphic assessment data from this study as a baseline for measuring long-term erosion/deposition changes to the channel geometry at the same locations.

The reaches needing rehabilitation were prioritized, with the highest priority sites targeted for conceptual-level design. The RSAT stations were used as the initial inventory locations; however, stream reaches in need of rehabilitation often extended over consecutive RSAT stations. Site characteristics such as length of impacted reach and adjacent vegetation were also documented. The following provides a description of the major categories used in the inventory to document conditions at each location:

Overall RSAT Score: Overall RSAT score for each rehabilitation site. For rehabilitation sites that are comprised of adjacent RSAT stations, this figure represents the average of two or more stations.

RSAT Score for Channel Stability: RSAT Channel stability score for each rehabilitation site. For rehabilitation sites that are comprised of adjacent RSAT stations, this figure represents the average of two or more stations.

Length of Study Area: "Study Area" is defined as the length of stream which will be studied for rehabilitation design purposes. A distance of 400 feet has been assigned as the study length for each RSAT station because this is the distance between RSAT points. Consecutive RSAT stations in need of rehabilitation will have study lengths equal to (# of consecutive data points) x (400).

Length of Treatment Area: "Length of Treatment Area" (LTA) is defined as that portion of the study area which will likely receive rehabilitation treatment. Because designs for rehabilitation have not been developed for these areas, it is estimated that 60% of the study area is in need of rehabilitation. Therefore, LTA is equivalent to (study area) x (0.60).

Adjacent Vegetation Type: Refers to vegetation types adjacent to rehabilitation sites; described as "forest," "shrub," "turf," or combinations thereof.

Access for Construction: Access is described as "good," "fair," or "poor" based on land ownership of the access and treatment areas, and whether sensitive natural resources such as forests, streams, or wetlands would be affected during access or construction work..

Affected Facilities and Resources: Refers to public and private resources and facilities such as utility lines, pathways, roadways, and recreational features which are in jeopardy due to existing stream conditions (erosion).

Potential Rehabilitation Techniques: Potential rehabilitation techniques are provided for each treatment area. Techniques are based on notes and photos taken during RSAT field work, as well as the Rosgen stream type and adjacent vegetation. These are preliminary suggestions only, and are subject to change based on further investigation and/or design.

Estimate of Cost per Linear Foot for Construction: Estimated costs are based on "potential rehabilitation techniques" listed for each treatment area according to the following scale:

Bioengineering	$50/l.f.
Boulder Revetment	$100/l.f.
Root Wad Revetment	$125/l.f.
Imbricated Rip-Rap	$150/l.f.
Grade Control	add $25/l.f.
Channel Realignment	add $50/l.f.
Remove Existing Structures	add $50/l.f.
First Order Stream	add $0
Second Order Stream	add $0
*Third Order Stream	add $25/l.f.
*Fourth Order Stream	add $50/l.f.

* Increases in cost are due to larger stream size, which influences grading and material costs, as well as care of water costs.

Estimate of Total Cost for Construction: Total construction costs are determined by multiplying the LTA by the estimated construction costs per linear foot. Since both the LTA and construction costs are estimates, these figures should be considered preliminary. Actual treatment lengths, techniques, and costs will vary. For rehabilitation sites comprised of consecutive RSAT stations, the estimate of total construction costs is based on the average linear foot of construction costs multiplied by the LTA.

Table 4.1 provides a summary of the rehabilitation inventory, providing quantitative and qualitative observations that were made during field and office analysis.

Table 4.1 Watts Branch RSAT Project: Stream Rehabilitation Inventory

Rehab Site #	Rsat Score: Channel Stability	Overall Rsat Score	Length of Study Area	Length of Treatment Area (ft.) (SA x .60)	Adjacent Vegetation Type	Access for Construction	Affected Facilities and Resources	Potential Rehabilitation Techniques	Estimated Cost per Linear Foot (Construction)	Project Cost Estimate (Construction Only)
102-1	5	24	≤400'	240	turf	poor* (golf course)		bioengineering approach: bank shaping, plant banks with woody vegetation	$50	$12,000
103-1 103-2	3.5 (avg.)	27 (avg.)	≤800'	480	turf with shrubs	good		bioengineering approach: minor bank shaping, toe protection, plant banks with woody vegetation	$50	$24,000
103-5	2 (avg.)	18.25 (avg.)	≤1,600'	960	forest	fair		bank shaping with root wads, imbricated rip-rap, or boulder revetment	$168.75 (avg.)	$162,000
103-6					forest		swim club (pool)	imbricated rip-rap or boulder revetment; grade control		
103-7					turf with shrub		gas utility	imbricated rip-rap, or boulder revetment; grade control		
103-8					forest			severe bank erosion; root wads, imbricated rip-rap, boulder revetment, grade control		
105-2	2	19	≤400'	240	forest	poor* (Thomas farm)		severe bank erosion; root wads, imbricated rip rap, boulder revetment	$150	$36,000
106-4 106-5	2 (avg.)	27.5 (avg.)	≤800'	480	forest	poor* (Thomas farm)		eroded meander; bank shaping, toe protection, boulder revetment	$100	$48,000

Rehab Site #	Rsat Score: Channel Stability	Overall Rsat Score	Total Study Area (ft)	Length of Treatment Area (ft.) (SA x .60)	Adjacent Vegetation Type	Access for Construction	Affected Facilities and Resources	Potential Rehabilitation Techniques	Estimated Cost per Linear Foot (Construction)	Project Cost Estimate (Construction Only)
107-1	3	20	≤400	240	shrub	poor* (Thomas farm)		incised channel; bank shaping, root wads, boulder revetment	$150	$36,000
107-5	4	21	≤400	240	turf	fair		incised channel; bank shaping, remove ford crossing	$75	$18,000
109-4 109-5	3.5 (avg.)	17.5 (avg.)	≤800	480	forest, shrub& turf	poor* (King farm)		tortuous, eroded meander; channel relocation, boulder revetment root wads	$162.50 (avg.)	$78,000
					forest			toe protection using boulder revetment; remove existing 24" culvert		
110-4	9	27	≤400	240	turf	poor* (King farm)		gabion revetment; remove gabion, shape and plant banks with woody vegetation	$100	$24,000
115-2 115-3	3 (avg.)	28 (avg.)	≤800	480	forest	fair		erosion upstream of culvert; channel realignment, boulder revetment, root wads	$175	$84,000
								severe erosion; grade control, stabilization may not be feasible		

Rehab Site #	Rsat Score: Channel Stability	Overall Rsat Score	Total Study Area (ft)	Length of Treatment Area (ft.) (SA x .60)	Adjacent Vegetation Type	Access for Construction	Affected Facilities and Resources	Potential Rehabilitation Techniques	Estimated Cost per Linear Foot (Construction)	Project Cost Estimate (Construction Only)
115-5	4	23	≤400	240	forest	fair		minor erosion threatening residential property; boulder revetment	$100	$24,000
115-7	3	21	≤400	240	forest	fair		severe erosion; root wads, boulder revetment	$125	$30,000
115a-1	3.66 (avg.)	22 (avg.)	≤1200	720	forest	fair	sanitary sewer utility	toe protection using root wads, boulder revetment	$117 (avg.)	$84,240
115a-2								erosion from fallen tree; remove tree, toe protection, boulder revetment, root wads		
115a-3								minor erosion on intermittent channel; boulder revetment		
117-5	2	16	≤400	240	forest	fair		incised, severely eroded; grade control, toe protection, boulder revetment	$125	$30,000
118-1	5	34	≤400	240	forest	poor		debris jam reducing channel capacity; remove blockage	$50	$12,000
118-4	3	10	≤400	240	forest	fair		bank shaping, boulder revetment, grade control	$125	$30,000

<table>
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<tr><th>Rehab Site #</th><th>Rsat Score: Channel Stability</th><th>Overall Rsat Score</th><th>Total Study Area (ft)</th><th>Length of Treatment Area (ft) (SAx.60)</th><th>Adjacent Vegetation Type</th><th>Access for Construction</th><th>Affected Facilities and Resources</th><th>Potential Rehabilitation Techniques</th><th>Estimated Cost per Linear Foot (Construction)</th><th>Project Cost Estimate (Construction Only)</th></tr>
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(avg.)</td><td rowspan="5">25.8
(avg.)</td><td rowspan="5">≤2,000</td><td rowspan="5">1200</td><td>forest</td><td rowspan="5">fair</td><td></td><td>eroded meander; imbricated rip-rap, root wads, boulder revetment</td><td rowspan="5">$130
(avg.)</td><td rowspan="5">$156,000</td></tr>
<tr><td>201-2</td><td>forest</td><td></td><td>discrete erosion along meander; spot treatment using imbricated rip-rap, boulder revetment; remove in-stream debris</td></tr>
<tr><td>201-3</td><td>forest</td><td></td><td>discrete erosion; spot treatment using imbricated rip-rap, boulder revetment; grade control</td></tr>
<tr><td>201-4</td><td>forest</td><td></td><td>erosion downstream of gabion check dam; imbricated rip-rap, boulder revetment, grade control</td></tr>
<tr><td>201-5</td><td>turf</td><td></td><td>discrete erosion, channel blockage; spot treatment using bioengineering, remove debris jam</td></tr>
<tr><td>204-1</td><td>4</td><td>34</td><td>≤400</td><td>240</td><td>forest</td><td>fair</td><td>sanitary sewer utility</td><td>eroded sewer line crossing; re-encase sewer utility, minor channel relocation, grade control</td><td>$175*
(not incl. sewer re-encasement)</td><td>$42,000</td></tr>
<tr><td>204-5</td><td>5</td><td>33</td><td>≤400</td><td>240</td><td>forest</td><td>good</td><td></td><td>minor bank erosion; toe protection using boulder revetment</td><td>$100</td><td>$24,000</td></tr>
<tr><td>204-8</td><td>9</td><td>37</td><td>≤400</td><td>240</td><td>forest</td><td>good</td><td></td><td>gabion revetment; stable reach; investigate removing gabion</td><td>$200</td><td>$48,000</td></tr>
</tbody>
</table>

Rehab Site #	Rsat Score: Channel Stability	Overall Rsat Score	Total Study Length (ft)	Length of TreatmentArea (ft) (SAx.60)	Adjacent Vegetation Type	Access for Construction	Affected Facilities and Resources	Potential Rehabilitation Techniques	Estimated Cost per Linear Foot (Construction)	Project Cost Estimate (Construction Only)
205-1 205-2	5 (avg.)	37 (avg.)	≤800	480	forest	fair		continuous erosion; bank shaping, boulder revetment, root wads	$88 (avg.)	$42,240
								discrete areas of erosion; spot treatments using bioengineering		
205-5 205-6 205-7	4 (avg.)	23 (avg.)	≤1200	720	forest	fair		minor bank erosion; bank plantings	$75	$54,000
								debris jam causing siltation of riffle; remove blockage		
								erosion increasing downstream; grade control, boulder revetment		
205-8	non-rsat	non-rsat	≤400	240			outfall	failed reno-mattress & plunge pool; rehabilitate structure	N/A	N/A
205-9	6	23	≤400	240	shrub & grass	good		erosion along meander; bioengineering approach, willow posting	$50	$12,000
206-2	3	22	≤400	240	forest	fair		incised, eroded reach; grade control, boulder revetment, root wad	$175	$42,000

Rehab Site #	Rsat Score: Channel Stability	Overall Rsat Score	Total Study Length (ft)	Length of Treatment Area (ft) (SA x .60)	Adjacent Vegetation Type	Access for Construction	Affected Facilities and Resources	Potential Rehabilitation Techniques	Estimated Cost per Linear Foot (Construction)	Project Cost Estimate (Construction Only)
301-2 301-3 301-4	4.3 (avg.)	25.7 (avg.)	≤1200	720	forest	fair		minor erosion; bioengineering approach	$100 (avg.)	$72,00
							gas utility	continuous erosion; boulder revetment, root wads		
					turf		sewer utility	continuous erosion; bioengineering approach		
301-6	7	34	≤400	240	forest	fair		severe erosion below station; debris jam; remove blockage, imbricated rip-rap	$225	$54,000
302-3 302-4	4 (avg.)	24.5 (avg.)	≤800	480	forest	fair	sewer manhole	erosion along meander; debris jam; remove blockage, boulder revetment, root wads	$200	$96,000
302-6	8	32	≤400	240	forest	fair		grade control required for tributary	$50	$12,000
302-8	4	29	≤400	240	forest	fair		debris jam; erosion in utility ROW; remove blockage, bioengineering approach in ROW	$125	$30,000

Rehab Site #	Rsat Score: Channel Stability	Overall Rsat Score	Total Study Length (ft)	Length of Treatment Area (ft) (SA x .60)	Adjacent Vegetation Type	Access for Construction	Affected Facilities and Resources	Potential Rehabilitation Techniques	Estimated Cost per Linear Foot (Construction)	Project Cost Estimate (Construction Only)
302-12	5	38	≤400	240	forest	fair		erosion along meander; toe protection, boulder revetment	$125	$30,000
401-2	3.5 (avg.)	25 (avg.)	≤800	480	forest	fair		severe erosion; imbricated rip-rap	$225	$108,240
401-3							unidentified utility	in-stream blockage, toe erosion; remove blockage, boulder revetment, root wads		
401-5	4.5 (avg.)	22 (avg.)	≤800	480	mix	fair		debris jam; remove blockage	$100	$48,000
401-6					forest			continuous erosion; bank shaping, bioengineering approach		
401-8	4.5 (avg.)	26.75 (avg.)	≤1600	960	forest	fair		continuous erosion; toe protection, bioengineering approach	$144 (avg.)	$138,240
401-9								erosion along toe of banks; toe protection, boulder revetment		
401-10							gas utility	toe protection using boulder revetment, root wads, grade bank to allow access to floodplain		
401-11							bridge footer (toe path)	address erosion at bridge footer; boulder revetment		

Rehab Site #	Rsat Score: Channel Stability	Overall Rsat Score	Total Study Length (ft)	Length of Treatment Area (ft) (SA x .60)	Adjacent Vegetation Type	Access for Construction	Affected Facilities and Resources	Potential Rehabilitation Techniques	Estimated Cost per Linear Foot (Construction)	Project Cost Estimate (Construction Only)
401-15	3.66 (avg.)	26 (avg.)	≤1200	720	turf	fair		erosion along meander; bioengineering approach	$131 (avg.)	$94,320
401-16					turf			erosion from outfall; bioengineering approach		
401-17					forest			debris jam; continuous erosion; remove blockage, boulder revetment,		
401-18	non-rsat	non-rsat			forest			eroded, incised channel; bank shaping, toe protection, boulder revetment, root wads		

4.1.2 Ranking System

Two separate ranking systems were developed to evaluate and prioritize individual stream rehabilitation sites that were identified in the field. The first system was developed by ESA, based on the field information that was collected as part of the RSAT analysis. The second system was developed by the City and Watts Branch Partnership as a potential variation from the original ESA approach.

The first ranking system used criteria and assigned weighting values based on best professional judgement, input from the Watts Branch Partnership, City staff and experience. The following discussion provides the rationale for selecting the factors and assigning the weights for the first ranking system.

The output of the stream rehabilitation ranking system produced an overall score for each stream rehabilitation site based on a 100 point numeric scale, whereby the site with the highest overall score represents the best opportunity for stream rehabilitation.

ESA prepared the first ranking system, which was more technical and encompassed all known factors. The overall score is derived from the sum of individual scores based upon the following five evaluation categories:

- Channel condition
- The extent of the problem
- Public and community benefits
- Feasibility and access
- Project cost

The selection of stream rehabilitation sites also considers future activities in the watershed, especially stormwater retrofits, stream buffer enhancement, and other restoration and rehabilitation projects. These considerations were used to further prioritize the sites which receive the highest scores from the ranking system (in other words, a "second tier" ranking process) to favor those which are or will be located in proximity to other watershed rehabilitation projects. Table 4.2 presents the criteria and associated points.

Table 4.2 Watts Branch Stream Rehabilitation Ranking System by ESA

1.	**CHANNEL CONDITION** (**35%** of total score)		**Score**
1a.	RSAT Score for Channel Stability at the rehabilitation Site:	9-11	2
		6-8	5
		3-5	10
		0-2	15

1b.	RSAT Score for Channel Stability immediately upstream of the rehabilitation site:	9-11	10
		6-8	6
		3-5	4
		0-2	1
1c.	Overall RSAT score upstream of rehabilitation site (Avg. of 3 sta. above) (If no station above, then score 5):	42-56	10
		26-41	6
		16-25	4
		0-15	1

2. EXTENT OF PROBLEM (**30%** of total score)

2a.	Length of treatment area:		
		<250 linear feet	2
		251-500 linear feet	4
		501-750 linear feet	6
		751-1000 linear feet	8
		>1000 linear feet	10
2b.	Stream size at rehabilitation site:		
		First Order	1
		Second Order	2
		Third Order	3
		Fourth Order	5
2c.	Bank erosion threatens meadow/grassed area		1
	Erosion threatens forested area (non-wetland)		3
	Erosion threatens scrub/shrub wetland		3
	Erosion threatens forested wetland		5
2d.	No maintained resources threatened		0
	Erosion threatens recreational feature (path, ballfield, etc.)		2
	Erosion threatens storm drain outfall or utility feature (gas, water, sewer, etc.)		4
	Erosion threatens private property/structure		6
	Erosion threatens transportation infrastructure (road, bridge, culvert)		10

3. LAND OWNERSHIP AND ACCESS (20%of total score)

3a.	Rehabilitation site on privately owned land	1
	Rehabilitation site includes both public and private land	5
	Rehabilitation site on publicly owned land or within public drainage easement	10
3b.	Access for Construction:	
	Poor access requires crossing of private property	0
	Fair access is through non-City easement and/or impacts sensitive natural resources	5
	Good access entirely on public land or City easement and requires no impacts to sensitive natural resources	10

4. PROJECT COST (15% of total score)

Cost per linear foot of rehabilitation (construction only):

>$175	linear foot	1
$125-175	linear foot	5
$75-124	linear foot	10
<$ 75	linear foot	15

TOTAL POSSIBLE SCORE 100

Upon request of the Partnership, City staff developed a second ranking system that simplified the selection variables for stream rehabilitation. The revised system focused on issues that most concerned the Partnership members: length and severity of erosion, ownership of the stream and forest/tree impacts from the construction. These variables indicated both the relative need for stream stabilization and the most significant costs and difficulties associated with a proposed project. They also showed the widest range among the ranking criteria. The relative point award distribution for each of the four categories for the second ranking system is presented in Table 4.3. Table 4.4 presents the raw data that were used to determine the relative site rankings under the simplified stream project ranking approach. An April 19, 2000 memorandum was prepared by City staff and provided to the Partnership describing the simplified stream project ranking system. This memorandum is listed in Appendix F and is part of the overall project record.

Table 4.3 Watts Branch Revised Stream Rehabilitation Ranking System by City and Partnership

1.	**LENGTH OF CHANNEL EROSION** (**25%** of total score)		**Score**
		400'	5
		800'	10
		1200'	15
		1600'	20
		2000'	25
2.	**RSAT CHANNEL STABILITY** (**25%** of total score)		
		5-11.0	6.25
		4.0-4.9	12.5
		3.0-3.9	18.75
		0.0-2.9	25.0
3.	**LAND OWNERSHIP** (**25%**of total score)		
		Private 0	
		Both	15
		Public	25
4.	**FOREST IMPACTS FROM CONSTRUCTION** (**25%** of total score)		
		>400'	0
		100-399'	10
		1-99'	20
		0 (No Impacts)	25
	TOTAL POSSIBLE SCORE		**100**

A summary of the results of the first (ESA) and second (revised) ranking systems are provided below.

4.1.3 Priority of Sites Based on Ranking System

Table 4.5 and 4.6 present the results of the ESA and revised City rehabilitation ranking analyses, respectively. The ranking system was applied to each of the 35 rehabilitation sites (the reader is reminded that the 62 RSAT stations identified as needing stream stabilization were combined into 35 rehabilitation sites due to the proximity of several stations to one another), based on a spreadsheet analysis that used the data collected as part of the field inventory and office analysis (Table 4.1). Sites have been sorted from highest to lowest score; highest score represents the greatest potential benefit from stream rehabilitation.

Table 4.4 Simplified Stream Project Ranking System Raw Data

Project ID	Length of Project (ft)	RSAT Channel Stability	Ownership	Forest Impacts from Construction (ft)
102-1	400	5	private	0
103-1&2	800	3.5	public	0
103-5 to 8	1600	2	both	0
105-2	400	2	private	30
106-4&5	800	2	private	600
107-1	400	3	private	0
107-5	400	4	public	50
109-4&5	800	3.5	private	0
110-4	400	9	private	0
115-2&3	800	3	public	600
115-5	400	4	public	350
115-7	400	3	public	40
115a-1 to 3	1200	3.66	public	100
117-5	400	2	public	75
118-1	400	5	public	150
118-4	400	3	public	50
201-1 to 5	2000	4.6	private	300
204-1	400	4	public	250
204-5	400	5	public	0
204-8	400	9	public	100
205-1 & 2	800	5	public	500
205-5 to 7	1200	4	public	400
205-8	400	-	public	400
205-9	400	6	private	0
206-2	400	3	public	100
301-2 to 4	1200	4.3	public	0
301-6	400	7	both	0
302-3 & 4	800	4	public	0
302-6	400	8	public	0
302-8	400	4	public	0
302-12	400	5	public	700
401-2 & 3	800	3.5	public	500
401-5 & 6	800	4.5	public	0
401-8 to 11	1600	4.5	public	450
401-15 to 18	1600	3.66	public	0
Total	24800			

Table 4.5 Stream Rehabilitation Sites: Descending Order Ranking by ESA

Rehab Site	Ranking Criteria										
	1a.	**1b.**	**1c.**	**2a.**	**2b.**	**2c.**	**2d.**	**3a.**	**3b.**	**4.**	**Total**
103-1/2	10	10	4	4	1	1	0	10	10	15	**65**
301-2/4	10	6	6	6	3	3	4	10	5	10	**63**
401-8/11	10	4	6	8	4	3	4	10	5	5	**59**
115a-1/3	10	4	5	6	1	3	4	10	5	10	**58**
205-5/7	10	6	4	6	2	3	0	10	5	10	**56**
205-1/2	10	6	6	4	2	3	0	10	5	10	**56**
401-5/6	10	4	6	4	4	3	0	10	5	10	**56**
401-15/18	10	6	6	6	4	3	0	10	5	5	**55**
302-6	5	4	6	2	3	3	0	10	5	15	**54**
204-5	10	6	6	2	2	3	0	10	5	10	**54**
103-5/8	15	1	4	8	1	3	6	5	5	5	**53**
302-3/4	10	6	6	4	3	3	4	10	5	1	**52**
204-1	10	4	6	2	2	3	4	10	5	5	**51**
117-5	15	4	5	2	1	3	0	10	5	5	**50**
302-12	10	6	6	2	3	3	0	10	5	5	**50**
115-5	10	4	4	2	1	3	0	10	5	10	**49**
201-1/5	10	6	6	10	2	3	0	1	5	5	**48**
302-8	10	4	6	2	3	3	0	10	5	5	**48**
115-2/3	10	6	4	4	1	3	0	10	5	5	**48**
107-5	10	4	4	2	1	1	0	10	5	10	**47**
401-2/3	10	1	4	4	4	3	4	10	5	1	**46**
118-1	10	1	4	2	1	3	0	10	0	15	**46**
106-4/5	15	6	6	4	1	3	0	1	0	10	**46**
206-2	10	4	4	2	2	3	0	10	5	5	**45**
115-7	10	4	5	2	1	3	0	10	5	5	**45**
118-4	10	4	5	2	1	3	0	10	5	5	**45**
105-2	15	10	6	2	1	3	0	1	0	5	**43**
102-1	10	4	5	2	1	1	0	1	0	15	**39**
205-9	5	4	4	2	2	1	0	1	5	15	**39**
204-8	2	6	6	2	2	3	0	10	5	1	**37**
301-6	5	5	5	2	3	3	0	5	5	1	**34**
109-4/5	10	4	5	4	1	3	0	1	0	5	**33**
107-1	10	4	6	2	1	3	0	1	0	5	**32**
110-4	2	4	4	2	1	1	0	1	0	10	**25**
205-8	NA			2	2		0	10	5	--	**NA**

NA = non-RSAT site

Table 4.6 Stream Rehabilitation Sites: Revised Descending Order Point Ranking by City and Partnership

Project ID	Length of Project	RSAT Channel Stability	Ownership	Forest Impacts from Construction	Total Score
401-15 to 18	20	18.75	25	25	88.75
103-5 to 8	20	25	15	25	85
103-1&2	10	18.75	25	25	78.75
301-2 to 4	15	12.5	25	25	77.5
117-5	5	25	25	20	75
302-3 & 4	10	12.5	25	25	72.5
401-5 & 6	10	12.5	25	25	72.5
115-7	5	18.75	25	20	68.75
115a-1 to 3	15	18.75	25	10	68.75
118-4	5	18.75	25	20	68.75
302-8	5	12.5	25	25	67.5
107-5	5	12.5	25	20	62.5
204-5	5	6.25	25	25	61.25
302-6	5	6.25	25	25	61.25
206-2	5	18.75	25	10	58.75
401-8 to 11	20	12.5	25	0	57.5
109-4&5	10	18.75	0	25	53.75
115-2&3	10	18.75	25	0	53.75
401-2 & 3	10	18.75	25	0	53.75
115-5	5	12.5	25	10	52.5
204-1	5	12.5	25	10	52.5
205-5 to 7	15	12.5	25	0	52.5
301-6	5	6.25	15	25	51.25
105-2	5	25	0	20	50
107-1	5	18.75	0	25	48.75
201-1 to 5	25	12.5	0	10	47.5
118-1	5	6.25	25	10	46.25
204-8	5	6.25	25	10	46.25
205-1 & 2	10	6.25	25	0	41.25
205-9	5	6.5	0	25	36.5
102-1	5	6.25	0	25	36.25
110-4	5	6.25	0	25	36.25
302-12	5	6.25	25	0	36.25
106-4&5	10	25	0	0	35
205-8	5	-	25	0	-

The City's revised stream rehabilitation ranking system yielded similar results to the ESA system. Although projects moved up and down in the ranking order, it was generally not significant and most of the same sites qualified as "high priority" for rehabilitation. This revised City approach was useful, in that it quantified expected tree/forest impacts for access and construction, which were not explicitly defined under the ESA approach.

The highest scoring stream rehabilitation sites were mapped on a subwatershed basis to determine which specific subwatersheds of Watts Branch are likely to be a priority for implementation (see Section 5 for a detailed discussion). Based on the results of the ranking analysis and discussion between the City, Partnership, and the Center team, the 35 sites were broken into 2 tiers. Initially, 11 of the 35 sites were selected for further investigation (i.e., development of conceptual designs). However, to minimize negative implementation factors such as construction access and other disruptions/disturbances, an additional grouping of sites occurred to include some lower ranking sites in the top tier. The end result of this grouping was that 14 total sites (comprising nine separate projects) were targeted for further investigation. Table 4.7 presents a summary of the nine recommended projects and associated stream reaches.

Table 4.7 Stream Rehabilitation Projects

Project Number	Stream Station(s) Comprising Project	Description of Project
1	103-1 to 103-2 & 401-15 to 401-18	minor bank shaping, toe protection, plant banks with woody vegetation
2	301-2 to 301-4	boulder revetment, root wads, bioengineering
3	401-8 to 401-11	toe protection, boulder revetment, root wads
4	115a-1 to 115a-3, 302-6 , 302-8 & 302-3 to 302-4	toe protection, boulder revetment, root wads
5	205-5 to 205-8	bank plantings, removal of debris jams, boulder revetment
6	205-1 to 205-2, 302-12, & 204-1	bank shaping, boulder revetment, root wads, toe protection
7	401-5 to 401-6 & 401-2 to 401-3	imbricated riprap, boulder revetment, root wads, bank shaping
8	204-5	toe protection, boulder revetments
9	103-5 to 103-8	bank shaping, imbricated riprap, root wads, boulder revetment

4.1.4 Recommended Stream Restoration Projects

Detailed concept design drawings of the nine projects were prepared as part of the Phase II tasks. The plans and supporting details contain information such as plan view of the proposed rehabilitation components, limits of disturbance, construction and maintenance access, utility protection (if necessary), impacts to natural resources, and estimates of number of trees to be removed. The design information was presented to the Watts Branch Partnership and displayed at the two open houses by the City. Due to the size of the plans, they are not included in this report; however, the City maintains copies of the relevant information (see Appendix F for a listing of project support information not presented in this report). The major types of rehabilitation measures proposed are described below, followed by a description of each project.

Since stream erosion is an ongoing process, the actual extent of disturbance and techniques shown in the concepts will be adjusted to reflect conditions at the time of final design. The City may also conduct restoration of other reaches within the Watts Branch watershed should critical problems or opportunities arise outside of the proposed work areas. Also, if proposed SWM projects are not able to be implemented, downstream reaches may require additional or more extensive stream restoration than originally recommended in this study. DPW will re-evaluate these reaches during final design stage.

Neighborhood coordination will be done during final design stage, and should include notification to nearby residents, adjacent property owners, civic/homeowners' associations, local schools and garden clubs, affected parks users and environmental interests. Signs at proposed access and work areas should be posted to help alert the community of the coming project.

The City Forester will work closely with DPW to improve tree preservation on stream restoration projects. The Forest Conservation Plans will include standard practices such as root pruning and placing wood chips in construction areas within the critical root zones of trees to be saved. The City Forester has also designated potential reforestation/afforestation areas on some stream restoration concept plans that will be considered at final design.

Stream Stabilization Structure Descriptions

Imbricated Rip-rap: A very strong structural revetment constructed from large, rectangular shaped boulders which typically average 2'x3'x4' in size. Boulders are stacked to create walls which protect banks and vegetation. Used in situations to address severe erosion and/or where bank height exceeds 5 feet.

Step Pool Channel: Structure used to address head cuts and/or areas of severe slope. Typically constructed of large boulders similar to those used for imbricated rip-rap.

Root Wads: Natural material revetment constructed of root wads, logs, boulders, and vegetative cuttings designed to protect eroding banks and to provide aquatic habitat. As organic component of revetment deteriorates over time, roots of vegetative cuttings (shrubs)fill voids, thus providing long term stabilization. Can be installed in situations requiring cut, however, this technique is better suited to “fill” applications.

Single and Double Toe Boulders: Natural material revetment constructed from large stone (typically class III) which is stacked one or two high atop a footer boulder which is designed to protect stream banks. Well suited for shade applications, where bank grading is not desirable, and where bank heights are less than 5 feet.

Biologs: A true bioengineering approach which utilizes “logs” constructed of natural coconut fiber which provide bank protection and a rooting medium for both herbaceous and woody plants. Well suited for sunny applications where banks can be graded to provide stable aspects. with low to moderately tall banks (can also be used where tall banks can be graded).

Cross Vanes: A structure constructed of stone which is designed to provide grade control, to locally reduce width-depth ratios, to relieve lateral bank stress, to locally center the thalweg, and to provide in-stream habitat.

Rock Vanes: A structure constructed of stone which is designed to relieve stress from an eroding bank by directing the thalweg channelward, and to provide in-stream habitat. Well suited for use in areas where limited channel capacity may prohibit other revetment techniques.

Bar Sills: Structures constructed of stone which are designed to stabilize, enhance , or create depositional features.

The stream projects are grouped geographically in the list below. Refer to the Implementation Section (Section 5) of the study for recommended construction priority and grouping as individual projects. Wherever possible, the City will construct stream restoration concurrently with any recommended SWM projects for that subwatershed to improve the success of the stream projects.

Project 1

Site 103-1 and 103-2

General Description:
This reach is located immediately downstream of Hurley Avenue and continues to the confluence of this tributary and the main stem of Watts Branch. The channel in this area is generally narrow and incised with moderate to severely eroded banks. The majority of the riparian area is dominated by herbaceous plant communities, therefore, bioengineering techniques are available for use.

Stabilization Techniques:

- Biologs are proposed throughout this reach to address eroded banks. Larger diameter (20") logs are proposed where bank heights are taller than 4 feet. Standard diameter logs (12") are proposed in all other areas. All banks behind the logs are to be graded to 3:1. Seed, vegetative cuttings and biodegradable matting are to be placed on the graded slopes.
- Cross vanes are proposed to maintain existing channel invert elevations.

Access:
Access for construction will be provided from Hurley Avenue. Access pathways follow the channel and for the most part avoid existing trees.

Site 401-15, 401-16, 401-17 and 401-18

General Description:
This project consists of a segment of the mainstem of Watts Branch in the vicinity of the Watts Branch Parkway and Aintree Drive within Woottons Mills Park. The park in this area contains both forested and meadow communities which contain vast areas of potential nontidal wetlands. In general, this system is incised with low width to depth ratios. The channel inverts are in general well below the rooting zone, therefore, there is a significant amount of channel erosion. Where there is ample sunlight penetration, bioengineering techniques are utilized.

Stabilization Techniques:
- Double (stacked) biologs are proposed where there is ample sunlight to support vigorous plant growth. A stacked arrangement is proposed due to the significant bank heights which sometimes exceed 6' in height. As with all biolog applications, slopes behind the revetment should be graded to a 3:1 slope, matted, seeded and planted with vegetative cuttings.
- Double toe boulders are proposed to address bank erosion where there is too much shade to support a bioengineering approach. Grading is recommended behind this revetment to provide for a planting area.
- There is an existing debris blockage and a dilapidated USGS gage station which are impeding bedload transport and are causing lateral stress on the banks. These should be removed as soon as practical. As an alternative, consideration should be given to maintaining the USGS station for potential future use as a monitoring point to assess the effectiveness of upstream management efforts.
- There is an existing, exposed sewer manhole in the center of the stream adjacent to the existing Aintree stormwater pond. This feature is causing lateral stress on the banks, and poses a potential hazard in that it is vulnerable to damage. This feature should be relocated well beyond the limits of the channel.
- Imbricated walls (rip-rap) are proposed in one area where bank heights exceed 6 feet, and erosion is severe and is threatening the loss of trees at the top of the banks.

Access:
Access for construction will be provided from three locations: from Aintree Drive, from the tot-lot at the terminus of Aintree Drive, and from a park entrance off of Watts Branch Parkway. Access pathways follow existing macadam pathways, existing sewer right-of-ways, and open areas (where feasible) to avoid impacts to trees.

Project 2

Site 301-2, 301-3 and 301-4

General Description:
This project consists of a segment of the mainstem of Watts Branch in the vicinity of the intersections of Maryland Route 28, Watts Branch Parkway, and Hurley Avenue. In general, this system has a low sinuosity, is moderately to mostly stable, and offers moderate to good in-stream habitat.

Stabilization Techniques:
- Double toe boulders are proposed to address bank erosion due to a) shade conditions and b) the desire to protect existing trees and root systems. Minor channel adjustments are proposed downstream of Hurley Avenue.
- Cross vanes are proposed to center the thalweg and to maintain existing channel invert elevations.
- There is an existing, exposed gas pipeline located immediately upstream of the Hurley Avenue Bridge. This utility needs to be relocated to a lower elevation. A cross vane is proposed at this location to provide grade control.
- There is an existing mid-channel bar located approximately 400 feet upstream of the Hurley Avenue Bridge which is causing severe lateral stress on the banks. This is to be removed.

Access:
Access for construction will be provided from three locations: from Crofton Hill Lane, Maryland Route 28, and Hurley Avenue. Access pathways exist primarily in open areas, and have been designed to avoid the scattered trees which exist in the riparian areas.

Project 3

Site 401-8, 401-9, 401-10 and 401-11

General Description:
This project consists of a segment of the mainstem of Watts Branch located east of Wootton Parkway within Woottons Mill park, which is entirely forested. In general, this system is mostly stable, but is experiencing severe erosion along two adjacent, tortuous meanders.

Stabilization Techniques:
- Imbricated walls (rip-rap) are proposed in two areas where erosion is severe, and to prevent the channel from migrating over an existing sewer line.
- One small segment of rootwads is proposed along a portion of a meander where the channel is to be adjusted and the thalweg relocated streamward several feet. Rootwads are favored here due to the significant amount of encroachment/fill desired.
- Rock vanes are propose in three locations. Two are proposed within a tortuous meander to direct the thalweg and energy from the banks. The third is located immediately upstream of

a pedestrian bridge at the upstream limit of the project. This is intended to direct energy away from the bank and protect the bridge footer from scour.

Access:
Access for construction will be provided from two locations: from Greenplace Terrace and from Paulsboro Drive. Access pathways follow an existing sewer right-of-way and an existing macadam pathway to avoid impacts to trees.

Project 4

Site 302-3, 302-4, 302-6, 302-8, 115A-1 and 115A-2

General Description:
This project consists of a segment of the main stem of Watts Branch and a first order tributary within Woodley Gardens Park adjacent to Nelson Street. In general, the main stem of Watts Branch in this area is moderately stable with discrete areas of erosion along the outside of meander bends. The unnamed first order tributary is mostly unstable with areas of continuous, significant bank erosion. This system originates from a 48" concrete pipe adjacent to the cul-de-sac at Wilson Avenue which directs energy toward the left bank. In addition, this system is moderately incised in areas which requires consideration of capacity when finalizing rehabilitation designs.

Stabilization Techniques:
- Single and double toe boulders are proposed to address bank erosion on these reaches due to a) shade conditions and b) the desire to protect existing trees and root systems. Single toe boulders are used where bank heights are lower than 3 feet; double toe boulders are used in all other areas. Minor channel relocation is proposed where channel geometry is excessively tortuous.
- Cross vanes are proposed to center the thalweg and to maintain existing channel invert elevations.
- Rock vanes are propose in two locations. These are placed to direct energy away from the banks in areas where bank erosion is moderate and where channel capacity would be compromised by use of a boulder revetment.
- Imbricated walls (rip-rap) are proposed in areas where channel relocation is proposed, and where bank erosion is most severe.
- Existing debris blockages on the first order tributary are causing significant channel alterations and are interfering with bedload transport. These should be removed as soon as possible.
- There is an existing, failed sewer protection feature on the first order tributary which is constructed of grouted stone and is proposed to be removed. A cross vane is proposed downstream of the utility crossing to hold grade in this area.

Access:
Access for construction will be provided from Nelson Street and the park parking area off of Nelson Street. Access pathways will follow the existing macadam path, open areas adjacent to the channel, existing, unimproved pathways, and existing sewer right-of-ways in order to minimize impacts to trees.

Project 5

Site 205-5, 205-6, 205-7 and 205-8

General Description:
This project consists of a segment of a second order tributary which flows through Upper Watts Branch Park downstream of Gude Drive. In general, this system is moderately unstable with discrete areas of erosion along the outside of meanders. The channel has moderate to good access to its floodplain and is moderately tortuous. Channel capacity does not appear to pose a limitation, but still should be considered during the final design process.

Stabilization Techniques:
- Single and double toe boulders are proposed to address bank erosion on these reaches due to a) shade conditions and b) the desire to protect existing trees and root systems. Single toe boulders are used where bank heights are lower than 3 feet; double toe boulders are used in all other areas. Minor channel relocation is proposed where channel geometry is excessively tortuous.
- Cross vanes are proposed to center the thalweg and to maintain existing channel invert elevations.
- A step pool channel is proposed below an existing, eroded stormwater outfall which apparently drains portions of Fordham Street.

Access:
Access for construction will be provided from Fordham Street. Access pathways will follow existing, unimproved pathways through the park and a portion of an existing sewer right-of-way in order to minimize impacts to trees.

Project 6

Site 302-12, 204-1, 205-1 and 205-2

General Description:
This project consists of segments of second and third order streams within Upper Watts Branch Park which is entirely forested. In general, these segments are moderately sinuous, and are unstable with eroded banks along the outside of meanders.

Two storm drain outfalls showing signs of significant erosion along the drainage path between the end of the pipe and the stream channel were also identified and could be stabilized as part of that project. The two outfalls are located, respectively, at the end of Azalea Drive, and east of Aster Boulevard between Azalea Drive and Nelson Street. At the final design stage for the stabilization for stations 204-1 and 302-12, the City should investigate options to stabilize these outfalls, including bioengineering techniques (e.g., boulders and plantings) and extension of the storm drain outfalls. The benefits of stabilizing these outfalls must be weighed against the construction disturbance to the mature trees in the area. The City will need to work with the nearby residents to discuss these issues. The City should measure the existing eroded outfall channels to compare with conditions at the final design stage. If the channel sizes appear to have stabilized, only minor repairs and vegetative stabilization may be needed, which will minimize disturbance.

Stabilization Techniques:

- Single and double toe boulders are proposed to address bank erosion on these reaches due to a) shade conditions and b) the desire to protect existing trees and root systems. Single toe boulders are used where bank heights are lower than 3 feet; double toe boulders are used in all other areas. Minor channel relocation is proposed where channel geometry is excessively tortuous.
- Cross vanes are proposed to maintain existing channel invert elevations.
- One small segment of rootwads is proposed where the channel is to be adjusted and the thalweg relocated streamward several feet. Rootwads are favored here due to the significant amount of encroachment/fill desired.
- A step pool channel is proposed in an existing, high gradient, first order tributary which is currently severely eroded and incised.

Access:
Access for construction will be provided from two locations: The Cul-de-sac at the end of Azalea Drive and from Princeton Place. Access pathways for the most part follow existing, unimproved pathways in order to minimize impacts to trees.

Project 7

Site 401-2, 401-3, 401-5, and 401-6

General Description:
This reach is located on the main stem of Watts Branch immediately downstream of Wootton Parkway. In general, the stream is moderately stable with a tortuous geometry. In-stream habitat is fair to good, with several deep pools which provide excellent fishery habitat. Debris blockages are present which has caused localized channel widening and has disrupted bedload transport.

Stabilization Techniques:

- Bar sills are proposed in a straight reach which is excessively wide. The bar sills are placed in a depositional area and are designed to trap bedload to develop a side bar which will reduce channel width.
- Existing, failed sewer protection features which are constructed of grouted stone are proposed to be removed.
- Debris blockages are to be removed.
- Channel realignment is proposed to establish a stable geometry and to address several hundred linear feet of eroded banks along the outside of the meanders. Root wads and imbricated rip-rap are proposed in these areas to provide bank stability.
- Rock vanes are proposed in three locations. One is proposed upstream of a very large American Sycamore tree; this is intended to direct energy away from the root system. The other area is immediately upstream of the crossing of Scott Drive. These are intended to direct the thalweg and erosive energy from the right bank (looking upstream). The third area is located downstream of Scott Drive and the intention is to direct the thalweg away from the

bank, and to provide protection to the right bank in the area of the downstream-most sewer crossing.

- One cross vane is proposed at the upstream limit of a straight reach. The intended purpose is to enhance in-stream habitat and to alleviate lateral stress on the banks.
- Extensive sediment bars have formed on the concrete flume upstream of the Wootton Parkway bridge (RSAT 401-6), obstructing the bridge's conveyance under high flows. The sediment should be removed. Additionally, a portion of the underlying concrete slab should be removed to re-create a natural baseflow channel upstream of the bridge. This work should be coordinated with the future widening of Wootton Parkway.

Access:
Access for construction will be provided from the Wootton High School parking lot and from Scott Drive. Access pathways will follow existing sewer rights-of-way to minimize impacts to vegetation.

Project 8

Site 204-5

General Description:
This reach is located downstream of Carnation Drive on a second order tributary which flows through Upper Watts Branch Park which is entirely forested. In general, the stream is stable with discrete areas of bank erosion along the outside of meanders.

Stabilization Techniques:

- Single and double toe boulders are proposed to address bank erosion along this reach due to a) shade conditions and b) the desire to protect existing trees and root systems. Single toe boulders are used where bank heights up to 3 feet; double toe boulders are used in all other areas.
- Cross vanes are proposed at cross-over reaches to maintain existing channel invert elevations and to center the thalweg.

Access:
Access for construction will be provided from Carnation Drive. The access pathway follows an existing, unimproved pathway in order to minimize impacts to trees.

Project 9

Site 103-5, 103-6, 103-7 and 103-8

General Description:
This reach is located on a first order tributary downstream of Dundee Road. In general, this reach is moderately unstable and incised throughout with severely eroded banks.

Stabilization Techniques:

- Biologs are proposed in the upper-most portion of this reach to address eroded banks, which will graded to a 3:1 slope, matted, seeded and planted with vegetative cuttings. Biologs are suitable at this location due to low bank heights and the lack of trees in the riparian area.
- Cross vanes are proposed to maintain existing channel invert elevations.
- Double toe boulders are proposed to address minor to moderate bank erosion within forested areas due to a) shade conditions and b) desire to protect existing trees and root systems.
- Rock vanes are proposed in several locations. These are placed to direct energy away from banks in areas where bank erosion is minor to moderate and/or where channel capacity would be compromised by use of a boulder revetment.
- Imbricated walls (rip-rap) are proposed in areas where bank erosion is severe and where bank heights exceed 5 feet.
- A step pool channel is proposed in a straight reach where there is an existing, failing reno mattress.

Access:
Access for construction will be provided from three locations: Dundee Road, Wootton Parkway, and from Feather Rock Drive.

The priority stream rehabilitation and stormwater retrofit sites need to be closely coordinated so each site can benefit from the other. Section 5 presents recommendations on how to integrate these together into the final watershed management plan for Watts Branch.

4.1.5 Recommended Outfall Stabilization Projects

Numerous storm drain outfalls showed signs of significant erosion along the drainage path between the end of the pipe and the nearest stream channel. Two of these outfalls were identified near a stream restoration project already recommended in the study, and could be stabilized as part of that project. The two outfalls are located, respectively, at the end of Azalea Drive, and east of Aster Boulevard between Azalea Drive and Nelson Street. At the final design stage for RSAT stations 204-1 and 302-12, DPW will investigate options, including bioengineering techniques, such as boulders and plantings, and extension of the storm drain outfalls. The benefits of stabilizing these outfalls must be weighed against the construction disturbance to the mature trees in the area. DPW will work with the Neighborhood Resource Coordinator to discuss these issues with nearby residents.

DPW will also measure the existing eroded channels to compare with conditions at the final design stage. If the channel sizes appear to have stabilized, only minor repairs and vegetative stabilization may be needed, which will minimize disturbance.

Other storm drain outfalls are in need of repair and stabilization. As DPW surveys each stream reach at final design, outfalls in need of significant repair will be included in the proposed work.

4.2 Wetland Management Plan

A wetland management plan was developed to identify existing wetland areas where a functional improvement can be achieved through enhancement or restoration of existing conditions. Enhancement and creation opportunities identified in the plan relied on findings and observations from stormwater management retrofit and stream rehabilitation assessments, where opportunities for improving wetland function and other subwatershed conditions through wetland restoration and/or creation were presented. Candidate locations for improvement were selected based on the following criteria:

- RSAT and other field assessment recommendations for the location of wetland enhancement and creation;
- Proximity to intermittent and perennial stream channels (isolated wetland enhancement and creation opportunities were not considered due to marginal stream improvement potential);
- Potential for significant water quality improvement (the planting of trees and shrubs to enhance emergent wetlands was not recommended because thermal loading is not an issue in the Watts Branch Watershed);
- Location within hydric soil areas (NRCS Soil Survey for Montgomery County);
- Low lying, flat areas where grading work will be minimal;
- Non-forested areas (enhancement of forested wetlands and the clearing of upland forest for the creation of wetlands are not practical methods for improving water quality).

A description of each wetland improvement area including existing conditions, property ownership, enhancement/creation approach, and possible water quality benefits is provided below. Figure 4.2 shows the general location of the improvement areas. A full-sized plan map has been prepared using a variety of data sources including: hydric soil boundaries (from the NRCS Soil Survey for Montgomery County) and existing wetland areas (from the U.S. Fish and Wildlife Service National Wetland Inventory Map/Rockville Quadrant). The full-sized map is not included as part of this report, but has been provided to the City as part of the project record.

<u>Wetland Improvement Area Descriptions</u>

Area #1 This is a privately owned, open area adjacent to a small, perennial tributary of Watts Branch. The site abuts retrofit site SM-18 and is surrounded by a thin forested edge. Portions of this proposed area could be graded in conjunction with site SM-18 construction to increase floodplain storage and, where there are existing herbaceous wetlands, enhanced with native wetland trees and shrubs.

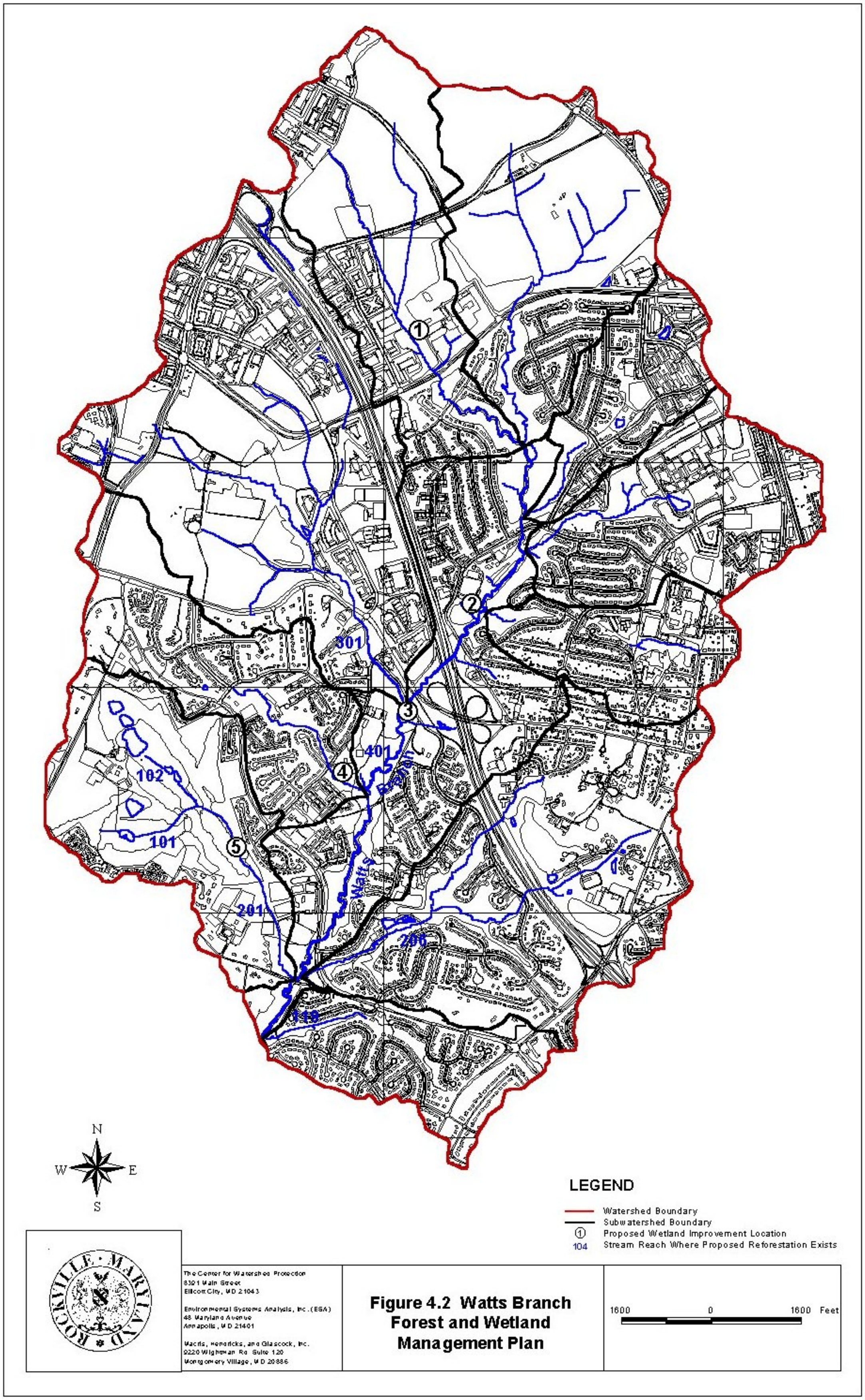
Area # 2 This site is located in Woodley Gardens Park and consists of a drainage ditch/swale with emergent wetland vegetation. This ditch drains an adjacent ballfield and, during storm events, it transports pollutants associated with turf maintenance (mainly fertilizer and pesticides) as well as some sediment. This swale should be enlarged as much as possible and the gradient should be reduced so that it can retain greater volumes of storm water. This will lessen pollutant flows to the receiving stream and lower peak flows. Native wetland plants and shrubs should be planted in the expanded ditch to maximize pollutant uptake. In addition, trees can be planted adjacent to the newly graded area to improve wildlife habitat and the overall aesthetic of the park.

Area # 3 This is an existing emergent wetland located at the northern end of Woottons Mill Park (public property). During storm events, an eroding channel carries overflow and sediment from the wetland into the adjacent stream. If this erosion is not checked, it will continue to pollute the stream and it could eventually drain the wetland. To preserve the wetland and improve water quality, the channel should be filled and stabilized. If necessary, grading work should be performed to lessen concentrated flows to the stream during storm events, thereby eliminating future channelization and erosion. Expansion of the existing wetland is also possible during the grading operation and is strongly recommended. The increase would provide greater storage capacity during storm events. Whether this wetland is an emergent, scrub shrub or a forested system is not critical. However, a forested system would be more in keeping with the natural wetland systems within the Watts Branch watershed.

Area # 4 This is an open area located at the southwestern tip of Woottons Mill Park. Its low elevation when compared to the adjacent stream makes it an excellent candidate for wetland creation. With minimal grading, this site can provide increased floodplain access for the stream thereby reducing sediment loads and erosive velocities during storm events. A forested wetland system would be more appropriate for this site and, therefore, woody wetland trees and shrubs are recommended.

Area # 5 This site consists of the open, low lying areas adjacent to the Watts Branch tributary which bisects the Lakewood Country Club golf course (private property). Run-off from the golf course can contain nutrients and pesticides. These pollutants can be filtered by enhancing the existing emergent wetlands and creating additional wetlands. Wetland enhancement can be accomplished by planting native wetland shrubs and trees for greater nutrient uptake. The development of a tree canopy will also reduce thermal loading. Wetland creation can be accomplished by performing minor grading to capture run-off before it enters the stream. These areas can then be planted with herbaceous or woody wetland species. A dense ground layer would be most desirable in these areas to slow the flow of water and to filter out suspended solids.

Figure 4.2 Wetland Improvement and Reforestation Management Plan



4.3 Forest Management Plan

A forest management plan has been prepared for the Watts Branch watershed in order to identify and enhance specific areas within the riparian corridor. Specifically, the plan targeted areas within 150 feet of perennial/intermittent streams to indicate gaps in the stream valley corridor greater than 1/4 acre. These criteria were established to ensure that the proposed forest areas would be large enough to be ecologically sustainable and wide enough to serve as an effective biological filter for water quality while not overextending the City's financial and human resources.

Open areas and 150 foot buffers were initially identified using a base map showing Watts Branch and its tributaries, the large forested tracts within the watershed (taken from the 1993 M-NCPPC GIS Land Use/Land Cover Map for Montgomery County), and the existing tree cover in the City of Rockville's parks (1999 City of Rockville Parks & Recreation Department survey). Reforestation recommendations were modified by removing areas slated for current or future development. Next, aerial photographs were used to identify playing fields, buildings, or other facilities within the recommended areas which would preclude their use. The aerial photographs were also used to identify any forest cover discrepancies on the base map. Finally, the RSAT data sheets for the entire watershed were reviewed to ensure that no reforestation opportunities were overlooked on the map and to eliminate any reforestation locations due to conflicting uses not apparent from the aerial photographs. The data sheets were also used to develop management recommendations (e.g., the presence of invasive species) and to compile the reforestation species recommendation list.

Public property reforestation opportunities have been separated from private opportunities. Public and private properties were identified using tax maps and the 1999 ADC map for Montgomery County. A summary of the private and public reforestation acreage within each Watts Branch tributary and specific management recommendations are provided in Table 4.8. Figure 4.2 shows the general locations of these areas. A full-sized plan map has been prepared but is not included as part of this report. The City has a copy of the map as part of the project record.

Reforestation/ afforestation plans are subject to approval by the City Forester. Location and spacing of trees, species selection and planting details must be included in an approved Forest Conservation Plan.

Table 4.8 Summary of Recommended Reforestation Sites

Stream Reach	Total Reforestation Acreage	Private Acreage	Public Acreage	General Notes
401	11.5	0.3	11.2	Mile-a-minute and Multiflora Rose management suggested.
119	3.4	3.4	-	-
206	7.9	-	7.9	-
201/101/102	6.5	4.2	2.3	Tall fescue and Multiflora rose management suggested.
301	4.8	4.8	-	-

<u>Reforestation Species Recommendations</u>

Based on the RSAT vegetation data and Brush, Lenk, and Smith's vegetation map of Maryland (G.S. Brush, C. Lenk, J. Smith, 1980. *The Natural Forests of Maryland: An Explanation of the Vegetation Map of Maryland*. Ecological Monographs), the stream valley forests in the Watts Branch watershed belong to the "Sycamore-Green Ash-Box Elder-Silver Maple" association. Other typical species in this association include: Red Maple (*Acer rubrum*), White Oak (*Quercus alba*), Flowering Dogwood (*Cornus florida*), Black Cherry (*Prunus serotina*), Northern Red Oak (*Quercus rubra*), Spicebush (*Lindera benzoin*), Tulip Poplar (*Liriodendron tulipifera*), Black Gum (*Nyssa sylvatica*), Sassafras (*Sassafras albidum*), White Ash (*Fraxinus americana*), Arrowwood (*Viburnum dentatum*), Black Oak (*Quercus velutina*), and Ironwood (*Ostrya virginiana*). A preliminary reforestation species list was compiled using a combination of typical "Sycamore-Green Ash-Box Elder-Silver Maple" association species and "RSAT" species. This list was then edited based on the following factors: nursery availability (some species are not even propagated); disease resistence; drought resistence; and light tolerance (some species can not handle the full sun exposure that reforestation areas are subject to). The final list is provided in Table 4.9. Species denoted with an asterisk (*) are dominant species. Each reforestation area should contain at least three dominant species and dominant species should make up 60 to 75% of the reforestation planting.

Table 4.9 Reforestation Species Recommendations

COMMON NAME	SCIENTIFIC NAME
Trees	
Box Elder*	*Acer negundo*
Silver Maple*	*Acer saccharinum*
Red Maple*	*Acer rubrum*
Birch	*Betula nigra*
Green Ash*	*Fraxinus pennsylvanica*
Sweet Gum	*Liquidambar styraciflua*
Tulip Poplar*	*Liriodendron tulipifera*
Black Gum	*Nyssa sylvatica*
American Sycamore*	*Platanus occidentalis*
White Oak	*Quercus alba*
Pin Oak	*Quercus palustris*
Northern Red Oak	*Quercus rubra*
Black Willow	*Salix nigra*
Understory & Shrubs & Vines	
Flowering Dogwood	*Cornus florida*
Persimmon	*Diospyros virginiana*
American Holly	*Ilex opaca*
Witchhazel	*Hamamelis virginiana*
Spicebush	*Lindera benzoin*
Arrowwood Viburnum	*Viburnum dentatum*
Black Haw	*Viburnum prunifolium*

* Dominant Species

Planting Recommendations

- **Size -** In general, planting should be performed using containerized plant material. Containers should be no less than 2 gallons and no greater than 5 gallons. Container stock smaller than 2 gallons can be easily overlooked by maintenance personnel and accidentally mowed. In addition, small stock is a desirable food source for deer. Plant stock larger than 5 gallons is expensive and often requires a much longer time to adapt to field conditions, meaning higher initial maintenance. Balled and burlapped (B&B) stock is not recommended due to the significant loss of root mass during the removal operation.

- **Planting Density/Spacing -** One to three gallon container plants should be installed at a rate of 350 per acre. Five gallon container plants should be installed at a rate of 200 per acre. These are the densities recommended in the State Forest Conservation Manual. Spacing between plants should be varied to lend a natural appearance to the reforestation area. Minimum spacing between shrubs should be 3 feet. Minimum spacing between trees should be 6 feet.

- **Site Preparation -** Reforestation areas should be free of all noxious, invasive, and allelopathic species prior to planting. The primary target species are: Multiflora Rose (*Rosa multiflora*), Japanese Honeysuckle (*Lonicera japonica*), Asiatic Bittersweet (*Celastrus orbiculatus*), Porcelain Berry (*Ampelopsis brevipedunculata*), Japanese Knotweed (*Polygonum cuspidatum*), Mile-a Minute (*Polygonum perfoliatum*), and K-31 Tall Fescue (*Fesctuca arundinacea*). Control of these species should be accomplished through physical and/or chemical means.

  Where reforestation is proposed for an area that is maintained as lawn, it is strongly recommended that the grass be sprayed with a non-selective herbicide such as “Round-up”. After the grass has died, the reforestation trees and shrubs may be planted. Finally, a mulch of 3" to 4" of leaves (the use of leaves collected from residences may be used) should be spread over the entire reforestation area to prevent the regrowth of grass and to provide a natural bed of organic matter. The grass **should not** be physically removed because its roots will hold the soil until the trees and shrubs become established.

  Reforestation areas that are not maintained as lawn but are dominated by a natural grassland community require special attention to prevent damage by voles and other rodents which eat bark and can girdle the trees. Since these rodents prefer feeding in areas where they are hidden by vegetation, it is essential to keep the grasses away from the trunks of the trees. This can be accomplished by mulching the base of the tree as recommended under “Planting Procedure” below and by periodically spraying a non-selective herbicide on weeds and grasses that grow within the mulch ring. Mowing of natural grassland communities to accomplish this control is not recommended.

- **Planting Procedure -** Planting should be conducted in accordance with the latest issue of the Landscape Contractors Association MD-DC-VA *Landscape Specification Guidelines* and as follows: backfill should consist of 1/4 organic matter (“Leafgro” or “Compro”) and 3/4 existing soil; fertilizer should not be used unless organic matter backfill is unavailable; a 3" deep, 3 foot diameter mulch ring shall be placed around each tree. Any vegetation within the mulch ring should sprayed with an herbicide prior to the application of the mulch and allowed to work before placing the mulch. Mulch shall be aged, hardwood mulch, dark brown in color, uniform in size and free of foreign matter.

Management Recommendations

- **Watering -** Periodic watering of reforestation plant material is essential during the first year or two after planting. This will ensure that the root system is sufficiently developed to sustain the plant during periods of drought. At least one watering every month from May to September is recommended. This schedule may need to be adjusted depending on weather conditions.

- **Invasive Control -** All reforestation areas should be periodically inspected (once or twice each year) for invasive exotic species that can rapidly outcompete young trees and shrubs (see “Site Preparation” for the most common species). Identified species should be removed using physical and/or chemical means.

- **Predation Control -** Where buck rub and rodent problems are severe, collars or sleeves can be placed around the tree trunks. These devices are generally made of plastic and there are a number of different designs. The best design depends on the size of the tree and the type of predation. Please note that these collars/sleeves are not the “tree tubes” that are sold for use with seedlings.

- **Access Control -** Careful thought should be given to the location of reforestation areas where pedestrian traffic is high. Pathways, even if those paths are not formally recognized, should not be blocked by a reforestation area or it will be vandalized. Where reforestation areas are located adjacent to high traffic areas and highly maintained areas, they should be protected by fencing. This will prevent the creation of new pedestrian paths through the reforestation area, lessen (but not eliminate) the chances of vandalism, and prevent lawn maintenance personnel from accidentally mowing these areas - signs, alone, are not a deterrent. Fencing can be permanent or temporary depending on the setting. Temporary fencing does not usually last more than a year, especially in high use areas where vandals will tear it down. Periodic repair will have to be figured into the cost. Fencing should remain for at least one year and probably two or three to ensure the establishment of the reforestation area. Permanent fencing is preferable, but is more expensive.

SECTION 5. WATERSHED MANAGEMENT RECOMMENDATIONS FOR WATTS BRANCH

A suite of stormwater retrofit and stream rehabilitation sites have been identified and prioritized for implementation in the Watts Branch watershed, as detailed in Sections 3 and 4, respectively. In this section, specific management recommendations are presented that target the watershed as a whole by recommending priorities for project implementation on a subwatershed basis.

It was previously established that, due to the existing conditions of the Watts Branch watershed, it falls under the "impacted" to "non-supporting" stream classification and that management approaches and expectations should be consistent with this designation. However, it is also important to establish some ambitious goals for rehabilitation as a component of an effective and successful management plan for an "impacted stream." The specific Watts Branch watershed protection goals (see Section 1.1) were developed with this in mind, and the management strategy presented in this Section strives to achieve the goals.

As past research and discussion has revealed, there are several watershed management tools available to help restore an "impacted" or "non-supporting" watershed. Some of the tools are "structural" practices that involve physical watershed control measures. Other tools are "nonstructural" practices that include citizen behavior modification to encourage pollution prevention, watershed stewardship education, reforestation, and aquatic buffer enhancement. An effective watershed plan should have a balance of both structural and nonstructural approaches to help achieve the goals, because it is unlikely to expect to realize these goals with a structural approach alone.

5.1 Watershed Assessment

In formulating a watershed management plan, it is necessary to review the findings of the analyses that have been conducted in an inclusive and integrated manner, so that consideration is given to a broad array of factors. For example, the Phase I work consisted of the stream channel assessment work, which contained four major elements: the stream channel enlargement analysis, the rapid geomorphic assessment (RGA), the rapid stream assessment technique (RSAT) and hydrologic modeling. Each of these elements contributes complementary data that help produce converging lines of evidence to form a foundation for developing the watershed plan.

As reviewed in Section 2.1, the stream channel enlargement assessment methodology yielded data on the amount of channel enlargement that has occurred over the last 35 to 40 years at ten distinct sampling stations in the watershed. In addition, the amount of current and historic impervious cover was estimated. The general conclusion from these studies is that the stream channels of Watts Branch have enlarged by as much as 100% since the early 1960's when land development started to become the dominant activity in the watershed. The more compelling finding, however, is that channel enlargement is continuing and is predicted to reach as much as four to six times the original cross-sectional area before reaching a state of quasi-equilibrium. The other important factor is the expected time frame for the channel to reach this condition. Based on the current average age of development and the time frame for alluvial channels to reach a more balanced condition, another 40 to 50 years of channel adjustment is expected.

These results have import influence in developing watershed management strategies. The most obvious is to recognize that the hydrologic characteristics have been altered sufficiently throughout the watershed to create conditions where channel enlargement is likely to continue. Knowing that this underlying tendency exists can help in making some specific management recommendations. Four key recommendations include:

- Since Watts Branch is only partially along in the channel evolutionary process, an extraordinary effort is warranted to provide as much stormwater management channel protection as possible.
- Recognizing that current and future development contributes to channel enlargement, future development (e.g., the Fallsgrove project) should be designed to maximize channel protection capability.
- Stream channel stabilization techniques will need to accommodate the physical characteristics tending towards future channel enlargement. In some cases stream rehabilitation strategies may need to "hard line" the channel to protect property, utility lines, trees, or other infrastructure, and in other areas, rehabilitation may utilize "softer" techniques that can adjust as channels tend towards a larger cross-section.
- Stormwater retrofit and stream channel stabilization projects should be linked where a downstream channel stabilization project will benefit from upstream retrofit projects where altered hydrology can be at least partially remediated.

The RGA data provide supporting or complementary evidence to help validate the enlargement data. All ten sampling stations are currently rated as either "in transition" or "in adjustment." This one-time "snap-shot" assessment confirms that Watts Branch stream channels are currently enlarging. The data suggest that widening is occurring at all ten sampling locations and there is about an equal split between sites experiencing aggradation and degradation. This seems to confirm the imbalance in hydrologic forces and sediment load (see Appendix A for a complete discussion of the channel enlargement theory).

The RSAT results also support the enlargement data. With very few exceptions, all sampling stations rated as either "good" or "fair" conditions, suggesting an identified impairment, but not yet so impaired as to impede all uses. Out of a total of 132 RSAT stations, 62 locations were identified as needing further investigation for possible stream rehabilitation.

As part of Phase I, hydrologic modeling was also performed to help confirm the hydrologic indicators from the channel enlargement investigation and to document the flow rates for a range of storms in various locations throughout the watershed (see Section 2.3). Another element of the hydrologic modeling is to show the effects of existing structures on peak flow rates and to provide a baseline to help assess the benefits of proposed retrofit structures. These data are the most useful in estimating the level of hydrologic control for the channel forming storm events (i.e., six month through 18 month events) throughout the watershed. The benefits of the proposed retrofits can be compared to "pre-developed" and "existing" flow rates to get a sense of the amount of channel protection control being provided.

As discussed in Section 1, the watershed has a current impervious cover of approximately 28% which is right in the range between an "impacted" and "non-supporting" stream. Since ample evidence exists that the watershed is impaired, but still rates at least a “fair” designation, the implementation of watershed rehabilitation measures will go a long way towards maintaining a viable water resource. In short, the watershed assessment stage of the project concluded that Watts Branch is very much a “restorable” watershed.

5.2 Structural Watershed Rehabilitation Using a Subwatershed Management Strategy

As described in Section 3, 54 candidate stormwater retrofits sites were originally identified (using available watershed mapping resources) and field investigated to verify technical feasibility and to identify the most likely management practice for each site (Appendix E contains the completed retrofit inventory form for each of the 54 candidate sites). Seventeen of the 54 candidate sites were abandoned after the field screening for a variety of reasons (again, see Appendix E). The remaining 37 sites were evaluated through a ranking process that involved the development of several alternative ranking techniques, a sensitivity analysis, and participation from the Watts Branch Partnership to arrive at a short list of projects to carry forward to Phase II. The process identified 18 candidate sites for further investigation through the development of detailed conceptual designs. Upon completion and presentation of the 18 concept designs to the Partnership, public, and regulatory agencies, three of these sites were removed from consideration. One site, SM-8 (Aintree Pond), is being improved at this time outside the watershed study process. This results in 14 sites as priority implementation projects for the watershed study.

As discussed in Section 4, 62 RSAT locations were identified as candidates for stream rehabilitation. The stream rehabilitation identification process combined RSAT sampling sites into a single stream rehabilitation reach where adjacent RSAT sampling sites indicated a need for stream channel rehabilitation and resulted in 35 separate stream rehabilitation project sites (see Table 4.4). Candidate stream rehabilitation sites were ranked based on a ranking system developed by ESA, the Center, City staff, and the Watts Branch Partnership. The City staff, ESA, and the Watts Branch Partnership agreed to carry forward sites in two categories; a first tier consisting of the top 11 sites and a second tier for the remaining sites. By combining multiple adjacent sites, nine distinct stream project areas went forward to the design concept stage.

Figure 5.1 illustrates the locations of the top 14 retrofit sites (SM-8 is also shown on the figure) and top nine stream rehabilitation sites still under consideration after concept review. This figure also illustrates 10 subwatersheds and where each project is located in the context of a subwatershed management strategy. While all 14 retrofit and nine stream rehabilitation sites are valid candidates for further investigation and design, the reality is that fiscal and staff resources limit the number of projects that can be implemented in a timely fashion. In addition, it is most appropriate to implement projects that complement each other and limit the overall disturbance of exiting natural resources as much as possible. It is therefore important to try to prioritize the implementation of these projects in a subwatershed context. In other words, sites that should be pursued first should be pursued in the context of the overall benefit to the watershed through a subwatershed management strategy and an approach that seeks to combine stormwater retrofits with other rehabilitation strategies.

Three parameters were evaluated to identify subwatersheds for high priority implementation: the current condition of riparian buffer within each subwatershed, the distribution of stormwater retrofits across the watershed as a whole, and the relative proximity of recommended stream rehabilitation sites downstream from recommended retrofit sites. Table 5.1 lists the subwatersheds recommended for priority implementation. Figure 5.1 shows the locations of the prioritized subwatersheds. It should be noted that there are additional considerations that may ultimately shift the priority implementation such as the efficiency of coordinating with other public works projects (e.g., sewer repairs and improvements), community issues and concerns (e.g., severe erosion correction and/or park program considerations), and wetland and forest area improvements. A brief discussion of each of the priority subwatersheds is provided below.

Subwatershed 204, while having among the best current riparian cover, contains three important stormwater retrofit sites (SM-18, SM-19, and SM-20) with the capability to substantially control a significant portion of the runoff from the contributing subwatershed. These three sites coupled with implementation of stormwater management on the King Farm, are upstream from three of the recommended stream rehabilitation sites (site 204-5, 204-1, and 302-12, downstream from SM-18, SM-19, & SM-20). Subwatershed 205 also has excellent riparian cover and has upstream stormwater management provided on the King Farm. Consequently, it is recommended to pursue stream rehabilitation sites 205-5 to 205-8, 205-1 to 205-2 and site 302-12 (this site is downstream to subwatershed 204 and 205).

Subwatershed 114 is the most impervious subwatershed in the study and it contains virtually no stormwater management controls (neither water quantity nor water quality control). Retrofit site SM-23 provides an opportunity to control and treat a portion of the runoff from this subwatershed, which will also benefit priority downstream rehabilitation sites. Site SM-22 is also in subwatershed 114 and, while located within a private office park, has the potential to contribute significant hydrologic controls. Finally, there is a direct link in subwatershed 115A where site O-3 is above the pipe leading to the stream rehabilitation site 115A-1 to 115A-3. Just below and above the confluence with the Watts Branch mainstem (tributary 302) is another stream rehabilitation site (302-3, 4 & 6). When combined with the upstream retrofit project and the stream rehabilitation work in subwatersheds 115A and 114, it makes sense to consolidate the construction in this area. In addition, stream rehabilitation site 302-3 to 302-6 will receive some benefits from upstream retrofit sites in subwatersheds 204, 205, and 115.

Subwatershed 119 is an opportunity to provide both water quality and channel protection storage for almost the entire subwatershed. While there are no stream rehabilitation sites associated with this priority subwatershed, it will nevertheless provide a benefit to downstream conditions.

Subwatershed 103 contains the retrofit sites SD-8 and SD-6, and two stream rehabilitation segments (sites 103-1 to 103-2; and 103-5 to 103-8). Based on the amount of existing stream channel degradation, the potential for at least partial control of channel forming storm events, and the potential for riparian buffer enhancement, it is our recommendation that subwatershed 103 be carried forward as a priority site.

Woottons Mill Park is experiencing significant erosion along the mainstem of Watts Branch, and has extensive stream rehabilitation proposed. Stream protection is vital along these reaches because of the large volume of runoff from many neighborhoods that have no SWM opportunities. The City's Watts Branch sanitary sewer trunk line, which parallels the mainstem, has been exposed in several locations. The Department of Public Works intends to stabilize these eroded reaches and repair the sewer manholes and lines before more serious damage occurs to the sewer line. Therefore, the stream rehabilitation projects from 401-8 to 401-11 and 401-15 to 401-18 are also listed as priority in the City's Implementation Schedule, although they are not part of a particular subwatershed.

Table 5.1 Recommended Subwatershed for Priority Implementation

Subwatershed Designation	Recommended Projects for Implementation	Justification
204	Stormwater retrofits: SM-18, SM-19 & SM-20 Stream rehabilitation sites: 204-5; and 302-12 to 204-1[1]	combines retrofits with downstream stream rehabilitation, and consolidates construction disturbances
205	Stream rehabilitation sites: 205-5 to 205-8; & 302-12, 205-1 to 205-2[2]	combines upstream stormwater management (King Farm) with downstream stream rehabilitation, and consolidates construction disturbances
114 & 115A	Stormwater retrofits: O-3, SM-23 and SM-22* Stream rehabilitation sites: 115A-1 to 115A-3; & 302-3, 302-4 to 302-8[3]	combines retrofits with downstream stream rehabilitation, and consolidates construction disturbances
119	Stormwater retrofits: SM-1, SM-2, and SM-3	downstream retrofits that provide water quality and channel protection treatment for the majority of the subwatershed
103	Stormwater retrofits: SD-8 and SD-6 Stream rehabilitation sites: 103-5 to 103-8; & 103-1 to 103-2[4] Riparian buffer enhancement	combines retrofits with downstream stream rehabilitation, buffer enhancement, and consolidates construction disturbances
Mainstem	Stream rehabilitation sites: 401-15 to 401-18, 401-8 to 401-11, 401-3 to 401-3, 401-5 to 401-6	combines upstream retrofits with stream rehabilitation to stem significant erosion and protect City sewer infrastructure

Notes:
* It is acknowledged that site SM-22 is privately owned. The City should work diligently with the owner to pursue this project.

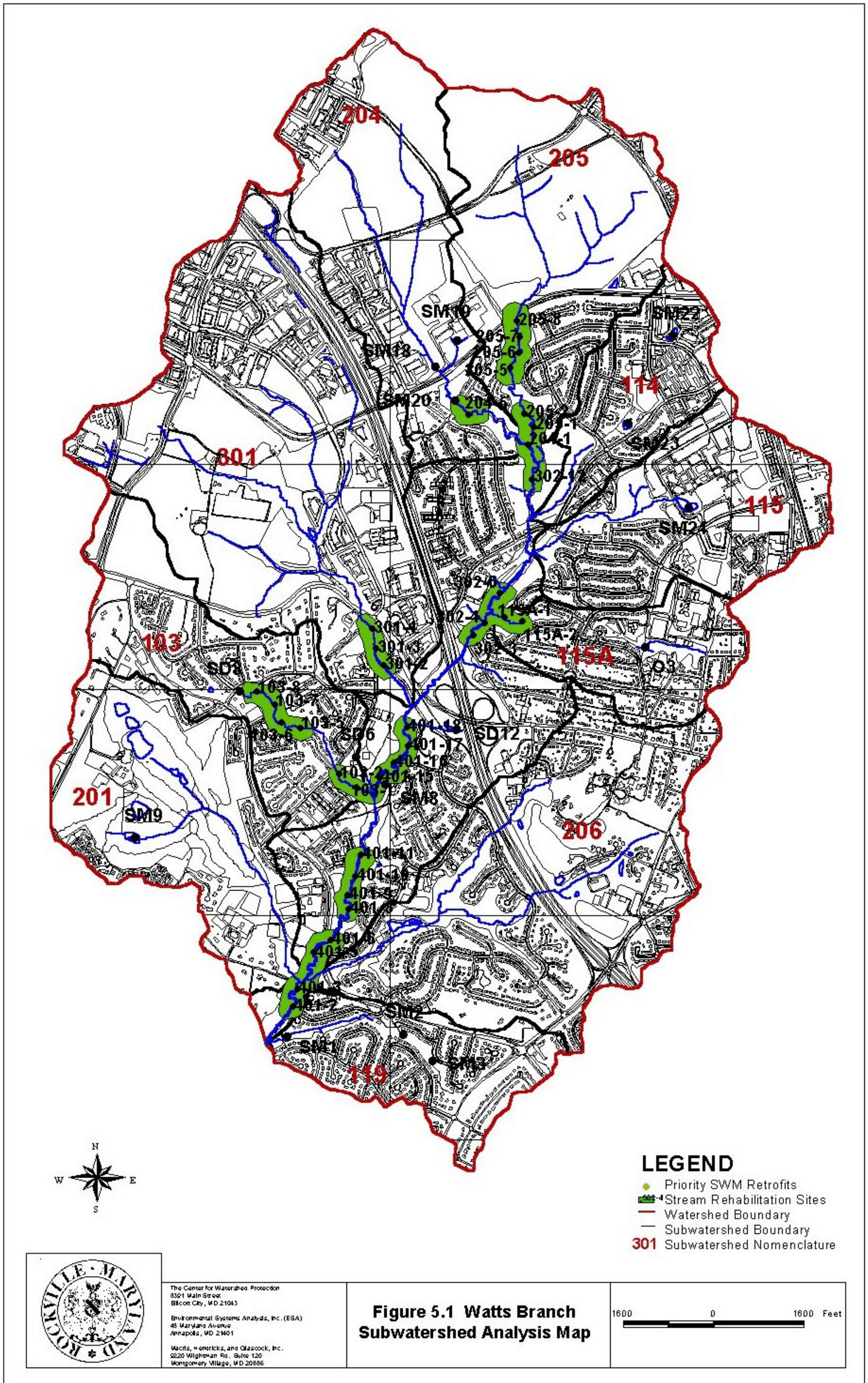
Option 1 Stream rehab. for site 204-1 would be combined with SM-20 to minimize construction disruptions

Option 2 Stream rehab. for site 205-1 & 205-2 combined as one reach with sites 302-12 to 204-1

Option 3 Stream rehab. for site 115A-1 to 115A-3 combined as one site with 302-3 to 302-6 to link disturbed areas and minimize construction disruptions

Option 4 Stream rehab. at site 103-1 & 103-2 would also include sites 401-15 to 401-18 to link disturbed areas and minimize construction disruptions

Figure 5.1Subwatershed Analysis Map



5.3 General Recommendations for Implementation

In addition to these specific subwatershed recommendations, the City and Center have developed the following general recommendations and guidelines to be aware of throughout the stormwater retrofit and stream rehabilitation implementation process.

- The SWM and stream restoration concepts offer guidance for final design. They represent staff's and the consultant's best recommendations at this time for overall watershed improvements. However, the concept designs are intended to be flexible, and will be re-evaluated at final design if SWM design standards or techniques have advanced. Further, staff will also consider revising SWM projects to take advantage of alternate locations or layouts if better opportunities present themselves, such as replacing a portion of a SWM pond on park land with an equivalent facility on available private land. Any revisions which substantially change a SWM or stream restoration project will be discussed with the staff team and the community.

- At the beginning of the Final Design phase, the City should schedule coordination meetings with representatives from the wetland/waterway regulatory agencies, including Maryland Department of Environment, the Army Corps of Engineers, and Maryland Department of Natural Resources, and any dam review agency, such as the Natural Resources Conservation Service, to obtain direction on permitting issues. All comments under individual projects regarding state/federal permitting issues reflect the wetland/waterway disturbance regulations as of 2000. These regulations and design criteria are subject to change. Projects must meet the regulations in effect at the time of the actual permit request.

- A City staff team, including the City Forester, the City Environmental Specialist, the Department of Recreation and Parks (R&P), the Neighborhood Resource Coordinators and the Project Implementation Coordinator, should meet as needed to ensure close coordination between departments and to develop plans for appropriate communication with the public.

- In keeping with DPW practice, local Homeowners'/Civic Associations, nearby residents and other interested parties such as Watts Branch Partnership members should be notified at the beginning of the Final Design stage and invited to comment on final design plans. Certain projects will need more formal or intensive community consultation to set priorities and resolve design issues as early as possible. Where necessary, the City will form a volunteer advisory group at the beginning of the Final Design stage to collect community feedback; interested residents and homeowners/civic associations should participate in this group to have their opinions considered.

- All sites will require a Natural Resource Inventory/Forest Stand Delineation and Forest Conservation Plan that comply with the requirements of the ordinance, including all revisions to the ordinance at the time the site is reviewed by the Development Review Committee.

- Most projects are expected to require 3:1 reforestation and significant tree replacement. Where possible, Forest Conservation Plan requirements shall be met on-site; if this is not feasible, they shall be met as close to the site as possible.

- 2 ½-3" caliper trees should be used as necessary to achieve a more mature appearance to reforestation areas.

- Since public acceptance of watershed improvements will, in part, depend on the attractiveness of the constructed SWM and stream projects, the City should plan for appropriate plantings, tree preservation and trash removal to maintain the performance and the setting of these projects. For example, high-quality, site-appropriate landscaping should be used and more frequent trash removal should be planned for SWM projects in high visibility areas or active parks.

- The SWM designs should emphasize aesthetic appeal wherever possible. Each site should be considered individually within the context of its surroundings. SWM ponds in wooded settings or in areas of heavy deer grazing may be more successful with a natural, wild appearance, whereas more formal landscaping may be appropriate for highly visible parks. At time of final design for ponds in highly visible areas, staff should investigate techniques to soften the riser and inflow structures, such as concrete tinting, facing and vegetative screening.

- DPW and R&P should start the process of developing cooperative maintenance and wildlife management plans for SWM sites located on City parkland. Cooperative management plans should be developed for all future SWM sites prior to construction.

- Safety fences are intended only to prevent very young children from gaining access to permanent pool areas, and are no substitute for appropriate adult supervision. Generally, fences are not advisable for online (i.e., in-stream) ponds because they may collect trash that could block the stream's baseflow. All SWM facilities will be designed with standard safety features, such as 3:1 slopes and safety benches at the permanent pool edge. Therefore, the City does not typically fence SWM facilities unless the community expresses a desire for this feature. Fences are typically chain link or split rail with attached wire fencing. The issue of safety fences around each pond should be discussed with the community at the time of final design.

- The City strives to balance SWM needs for developed areas against environmental and community impacts by placing new SWM facilities in locations with the least disturbance to natural resources, recreation features and active park usage areas, and to upgrade older SWM facilities. It is the City's policy to attempt to locate SWM on private property wherever possible so as to limit the impact of SWM facilities on City park space.

- Where practical, the City may recommend either retrofits of existing private SWM facilities or construction of new public SWM facilities on private land to provide regional SWM. These private sites will be recommended for regional SWM on a case-by-case basis, considering factors such as cost of the SWM facility itself, any land/easement purchases, site constraints, effectiveness of this and other local facilities in the sub-watershed, cooperation of the property owner and comments from nearby residents. In some circumstances, DPW may seek to use a private SWM facility as part of a series in the sub-watershed to reduce the size or need for SWM facilities on active park land or in high-priority natural resource areas.

- Funding for projects on private property will not necessarily be provided by the City. The Department of Public Works will work with private property owners as necessary to explore alternate funding opportunities, to cost-share or to coordinate improvements as part of the private development process. However, the City may implement a public SWM utility fee in the future to help fund land acquisition and/or regional SWM improvements on private property.

- The SWM concepts show conservative limits of disturbance to accommodate construction, staging and adjacent tree impacts. However, final limits of disturbance and tree removal are not decided until the final design and construction stage. The limit of disturbance may be smaller or slightly larger than shown in the concept. Some SWM concept sites were designed using detailed (2' contour interval) topography due to a concurrent topographic survey by R&P in some parks. Those designed with less detailed information (5' contour interval topography), including SM9, SM18, SM19, SM20, SM22, SM24, SD8, SD12, SD24 and O3, will need adjustments to conceptual grading and to the limits of disturbance to reflect more accurate information. The City Forester's staff will work with DPW to preserve as many trees as possible.

- Consider offering monetary incentives to contractors to save additional trees within the limit of disturbance during the construction phase. The intent would be to decrease the actual number of trees removed during construction within the expected clearing shown in final design plans. The City Forester would determine whether the trees have been adequately protected.

- The bio-engineering methods shown in the restoration concepts emphasize erosion control and aquatic habitat enhancement. Bio-engineering techniques may change in the course of project implementation and the City will incorporate other appropriate techniques in the final design plans as advisable. Similarly, should SWM design criteria evolve during the implementation phase, SWM concept details may be slightly altered, such as riser design or improvements to safety features. Any substantial changes to appearance shall be discussed with the community during the final design stage.

- The City should follow a performance monitoring plan for the watershed to evaluate gains over a ten to fifteen-year period. The performance indicators discussed in a later section of this report will help the staff determine whether the projects are meeting watershed management goals.

5.4 Watershed Education and Pollution Prevention Strategy

While the structural practices are an important component of the success of the Watts Branch Watershed Management Plan, an equally important component is a commitment to watershed education and pollution prevention strategies. This is particularly true in largely built-out watersheds such as Watts Branch, where opportunities for meaningful structural controls are limited and costly.
It has been a long standing tenet of stormwater treatment that it is more cost effective to prevent or minimize pollution at the source than to treat it once it is in the drainage and receiving water system. With any watershed restoration effort, the involvement of those that live and work in the watershed is vital to ensure long term success. Many people may be unaware of the impact of their actions on stream quality and aquatic habitats, and might be willing to make changes to those behaviors if they better understand the relationship between their individual behaviors and the water quality of the watershed they live in. By learning to eliminate actions that can produce non-point source pollution, concerned citizens can reduce the overall impacts of polluted stormwater runoff while creating a sense of partnership in the success of the watershed restoration plan.

The primary goal of the Watts Branch pollution prevention program is to alter current behaviors that contribute to pollutant loading within the watershed and assist in accomplishing the overall goals of the watershed restoration plan. The program will also benefit larger city-wide pollution prevention efforts. The use of public outreach and pollution prevention education efforts will allow those charged with implementing the watershed restoration plan to directly meet a number of the identified watershed protection goals for Watts Branch. Specific goals that can be targeted, in part, with a pollution prevention program include:

- Increase and expand local awareness both in and beyond the Watts Branch watershed.
- Reduce pollutant loads to Watts Branch, the Potomac River, and the Chesapeake Bay

In addition, public outreach can indirectly assist in meeting two additional goals of the plan.

- Protect riparian buffer, forest, and wetland zones
- Reduce stream channel erosion, and improve stream habitat

Advantages to incorporating these nonstructural stormwater practices into the Watts Branch Watershed Management Plan include:

- They are relatively inexpensive to implement in relation to structural stormwater practices.
- Some of the suggested practices only require behavior modification to ensure they result in less pollution runoff. In some of the more densely developed portions of the watershed, alterations in citizen behavior may be the best way to realize pollutant reduction targets.
- They encourage citizen and business involvement in the Watts Branch watershed restoration process, and foster a sense of ownership of the local watershed.
- For some of the recommended practices, organizations that can assist in outreach efforts are already present in the watershed (e.g., Watts Branch Partnership, HOAs).

5.4.1 Program Recommendations

Table 5.2 presents program recommendations for the City to consider. Pollution prevention program success starts with educating the public about watershed awareness and the importance of an individual's behavior on the health of a watershed. Pollution prevention programs coupled with the water quality benefit of the stormwater retrofits should help meet the water quality goals of the Watts Branch watershed as well as the downstream receiving waters (i.e., the Potomac River and Chesapeake Bay). While these program recommendations are targeted for Watts Branch, they also have applicability throughout the City. In fact, it may be easier and more efficient for the City to initiate a city-wide campaign.

Table 5.2 Nonstructural Pollution Prevention Program Recommendations

Program Recommendation	Program Components
Watershed Awareness	• Promote general awareness and responsibility of citizens with respect to being good stewards to their watersheds • Encourage and promote citizen activities around watersheds such as monitoring, tree plantings, "green-up" days, water conservation, clean ups and policing (e.g., reporting illegal dumping)
Pet Waste Management	• Signage and waste disposal stations • Fact sheets and limited media campaign
Lawn and Garden Care, Landscaping (Bay Scapes)	• Promotion of soil testing through Montgomery College • Recognize citizens using proper practices • Garden club and nursery outreach and education
Automotive Care (Car Washing and Maintenance)	• Promotion of washing on pervious surfaces and with minimum amounts of water • Proper disposal and recycling of used motor fluids
Good Housekeeping	• Promotion of proper disposal and/or recycling of household and commercial hazardous wastes
Disconnection of Directly Connected Impervious Areas	• Institute downspout disconnection and rain barrel program
Illicit Connection Detection and Removal	• Monitor and eliminate illicit connections in targeted commercial areas
Commercial Dumpster Management	• Locate away from storm drain inlets and riparian buffers • Promote/require use of enclosed holding areas

The Center has prepared general guidance on components of a pollution prevention and public education program outside of the framework of this Watts Branch study. The recommendations and guidance are general enough so that they can be customized for the particular needs of different watersheds within the City of Rockville and even different neighborhoods within a given watershed.

5.5 Watershed Indicator Monitoring

Having a method to assess the efficacy of the implemented watershed restoration measures and a basis from which to recommend modifications to the plan is a critical piece to the overall plan. A goal of the Center's recommended watershed management plan approach is to utilize stormwater indicators to the maximum extent practical to guide current and future management decisions. The recommendations are oriented towards conducting inexpensive, repeatable, and scientifically valid monitoring to assess future stream quality health. The monitoring of indicators will provide a key frame of reference and basis for updating and adjusting the Watts Branch Watershed Management Plan.

Traditionally, the focus of monitoring efforts to assess the quality of receiving waters has been end-of-pipe chemical and physical water quality criteria and analysis. In the last decade, however, many stormwater management professionals have begun to question the ability of traditional monitoring to accurately describe existing conditions in receiving waters, evaluate the overall integrity of aquatic communities, and assess the degree of improvement in stream systems. Instead, there has been a steady shift towards the use of “environmental indicators” to more accurately assess the condition(s) of receiving waters and the performance of stormwater management efforts.

Environmental indicators, although based on diverse measurements, when examined in combination, give a general indication of improvements or downturns in the environment and the effectiveness of resource management strategies. “Stormwater indicators” specifically focus on urban stormwater runoff impacts and can be used to assess the success (or failure) of stormwater management efforts.

A suite of six indicators (Table 5.3) has been identified and recommended to assess the efficacy of the Watts Branch Watershed Management Plan. As part of this project, baseline macroinvertebrate and fish data will be collected during the spring and early summer of 2001. These data will provide a benchmark from which to measure various aspects of the proposed management plan. A general description of the sampling effort is provided below; however, a separate protocol document for the proposed sampling and analysis will be developed and submitted to the City prior to the start of the field work.

Table 5.3 Stormwater Indicator Profile Categories

Indicator Category	Indicator Name
Physical and Hydrological Indicators	• Stream widening/downcutting • Physical habitat monitoring
Biological Indicators	• Macroinvertebrate and fish assemblage
Social Indicators	• Public attitude surveys • Public involvement and monitoring • User perception

5.5.1 Recommended Watts Branch Stormwater Indicators

The indicators, organized into three categories, represent both traditional and less frequently used assessment methods. A total of six indicators (Table 5.3) have been identified and recommended for implementation to assess the efficacy of the Watts Branch Watershed Management Plan. Descriptions of each group of indicators are provided below. Using the findings of the various indicator monitoring, the Watts Branch Watershed Management Plan will need to be modified and updated to more effectively achieve the goals of the plan. The indicator monitoring also provides opportunities for public involvement, which helps foster the ongoing process of watershed awareness and behavior modification.

Physical and Hydrological Indicators

Phase I of this study both supplemented and continued Dr. Leopold's work on channel enlargement response to impervious cover by utilizing historical cross-sectional surveys, combined with current cross-sectional measurements. It is recommended that this effort be continued at all ten stations, with the monitoring schedule dependent upon the stormwater retrofit construction implementation and the development of the King Farm and Fallsgrove parcels. Establishing monumented cross-sections at some of the 10 stations would strengthen the existing data set and provide a more reliable and repeatable measure of channel degradation or aggradation in the future.

The two Leopold stations (WAT 7 & WAT 8) are proposed to be installed with permanent monuments to provide both a horizontal and vertical definition of the channel evolution versus watershed imperviousness over time. This information will be combined with the biological data to provide an interpretive watershed trend. The information can also be used as a qualitative assessment tool of hydrologic response as a result of upstream stormwater management. For example, if a station cross-section (which is downstream of stormwater retrofits where channel protection storage has been provided) remains largely unchanged over an extended period of time (say 10 years), then it might be fairly assumed that the upstream retrofit has had an arresting effect on the channel enlargement process.

While not mandatory, the City may want to pursue re-establishing the USGS stream gage on the mainstem of Watts Branch at the upstream boundary of Woottons Mill Park to help assess flow trends and evaluate the efficacy of the watershed-wide modeling performed under Section 2.3 and 3.5. In addition, this location would be an excellent site for interpretive signage to help with watershed awareness. Signage might include historic Leopold photographs, cross-section comparisons, and habitat and stream gage data data.

In addition to monitoring the channel morphology, physical habitat can easily be monitored using the repeatable RSAT approach. With a quantitative score previously established at approximately 400-foot intervals along the length of stream, this assessment provides a useful basis for comparison with past surveys. Repeating the assessment in ten years to document changes in the watershed condition is recommended.

Biological Indicators

The historical biological and water quality data record for the Watts Branch watershed is much more sporadic than the record for channel enlargement analysis and comes from a variety of sources with differing formats. The information ranges from field observations to water chemistry analyses from both government agencies and private consultants. It is therefore recommended that a uniform monitoring protocol be established to initially obtain an adequate baseline data set so that accurate water quality trends are defined. Biological indicators represent an environmentally based method for assessing water quality that is inexpensive, repeatable and scientifically valid.

An advantage of using this indicator on Watts Branch is that Montgomery County already has a well established biological monitoring program and protocol in place (i.e., Index of Biological Integrity (IBI)). In addition, the County has previously sampled macroinvertebrate and fish assemblages in Watts Branch (downstream of the City of Rockville), thereby providing an existing database from which to draw some inferences.

Biological monitoring (biomonitoring) techniques are best used for detecting aquatic ecosystem impairments and assessing their relative severity. Furthermore, biomonitoring is an important tool for evaluating the effectiveness of control measures such as stormwater management retrofits and stream rehabilitation practices. Some specific advantages of using biomonitoring for watershed plan monitoring are:

- Biological communities reflect overall ecological integrity (i.e., chemical, physical, and biological integrity).
- Biological communities integrate the effects of different stressors and thus provide a broad measure of their aggregate impact.
- Communities integrate the stresses over time and provide an ecological measure of fluctuating environmental conditions.
- Routine monitoring of biological communities can be relatively inexpensive, particularly when compared to the cost of assessing toxic pollutants, either chemically or with toxicity tests.
- The status of biological communities is of direct interest to the public as a measure of a pollution free environment.

Two different assemblage groups are typically used in biomonitoring surveys and are recommended for the Watts Branch indicator monitoring, namely, macroinvertebrates and fish. The advantages of each assemblage group are described below:

Advantages of using macroinvertebrates:

- Macroinvertebrate assemblages are good indicators of localized conditions. Because many benthic macroinvertebrates have limited migration patterns or a sessile mode of life, they are particularly well-suited for assessing site-specific impacts (upstream-downstream studies).
- Macroinvertebrates integrate the effects of short-term environmental variations. Most species have a complex life cycle of approximately one year or more. Sensitive life stages will respond quickly to stress; the overall community will respond more slowly.
- Degraded conditions can often be detected by an experienced biologist with only a cursory examination of the benthic macroinvertebrate assemblage. Macroinvertebrates are relatively

easy to identify to family level, and many "intolerant" taxa can be identified to lower taxonomic levels with ease.

- Benthic macroinvertebrate assemblages are made up of species that constitute a broad range of trophic levels and pollution tolerances, thus providing strong information for interpreting cumulative effects.
- Sampling is relatively easy, requires few people and inexpensive gear, and has minimal detrimental effect on the resident biota.
- Benthic macroinvertebrates serve as a primary food source for fish, including many recreationally important species.
- Benthic macroinvertebrates are abundant in most streams. Many small first and second order streams, which naturally support a diverse macroinvertebrate fauna, only support a limited fish fauna.

Advantages of using fish:

- Fish are good indicators of long-term (several years) effects and broad habitat conditions because they are relatively long-lived and mobile.
- Fish assemblages generally include a range of species that represent a variety of trophic levels (omnivores, herbivores, insectivores, planktivores, piscivores). They tend to integrate effects of lower trophic levels; thus, fish assemblage structure is reflective of integrated environmental health.
- Fish are relatively easy to collect (possibly by volunteer stakeholders) and identify to the species level. Most specimens can be sorted and identified in the field by experienced fisheries professionals, and subsequently released unharmed.
- Monitoring fish provides direct evaluation of “fishability” and “fish propagation”, which emphasizes the importance of fish to anglers, bringing the stakeholders to the watershed.

It is recommended that the general Montgomery County macroinvertebrate sampling protocol and IBI be conducted at the nine stream rehabilitation sites proposed for Watts Branch to generate a sound baseline data set with subsequent monitoring folded around the watershed plan implementation schedule. Use of the IBI will allow stream reaches in the Watts Branch watershed to be objectively rated based on a standard criteria and will allow for comparison to other streams within the region. However, it is important to note that once watershed imperviousness exceeds 20% (Watts Branch watershed imperviousness in approximately 28%), IBI scores tend to score in the fair or poor category. Even after stormwater management retrofits and stream restoration, many stream reaches may still score in the fair or poor category when assessed with the IBI. In order to detect finer scale changes, individual metrics will be analyzed prior to scoring. For instance, a stream prior to restoration may support only 4 or 5 taxa of macroinvertebrates. After restoration the same stream may support 8 or 9 taxa. Based upon the IBI scoring criteria, both of these results would receive a score of 1 for the Taxa Richness metric. The IBI would indicate no improvement based on the scoring, but the stream would be supporting twice as many taxa. Utilizing both the IBI and the individual metric results will allow for an accurate assessment of watershed restoration activities.

In addition, it is possible that the macroinvertebrate community may shift in response to the hydrologic and thermal influence associated with stormwater management controls (e.g., from a lentic make up to a lotic influenced make up). IBI’s have a bias towards rating these “lotic” communities lower than lentic communities, and it is therefore important to be aware of this bias. This change in community make up should not necessarily be interpreted as a poorer condition of the stream, but instead should be evaluated in the context of the other indicators (e.g., physical and hydrological) and the fact that development in watersheds at levels comparable to Watts Branch will almost always result in a shift in the trophic status of the streams. For example, if the physical and hydrological indicators show that the habitat has improved and that channel enlargement has slowed, then a shift in the macroinvertebrate community is not necessarily an indication of declining stream health but rather a shift in trophic status as a consequence of watershed development and altered hydrologic regime.

A spring 2001 sampling period is proposed for the collection of a baseline data set. A separate protocol and "study design" document will be prepared prior to the monitoring period.

Social Indicators

While most social indicators have limited effectiveness due to their dynamic complexity and challenging goals, they are nevertheless critical indicators from the standpoint of educating and communicating with the public. Furthermore, social indicators are a necessity to increase local watershed awareness and expand it beyond Watts Branch.

Public attitude surveys are directed at targeted groups to assess general awareness of key water quality problems and willingness to finance (via government spending) restoration efforts. A targeted group is solicited with a direct mailout, an interview or other mechanism of communication to gather information regarding an existing or potential program. The results of a survey are usually compiled into a summary report which may, for example, indicate that the public believes urban runoff to be the most significant source of pollution in the watershed or that funding for restoration efforts should be increased. This information can then be used by decision makers in helping to formulate watershed management policy, develop restoration budgets and workplans, or implement stream restoration programs.

Public participation in stormwater programs is one measure of overall program effectiveness. Successful implementation of stormwater programs depends, in large part, upon the active support and participation of the public. Citizen monitoring programs, watershed stewardship groups, public education (including school curricula), participation in watershed education events (e.g., Earth Day, Watts Branch Trout Derby) are all components of public involvement programs. Other measures of public participation include participation in household hazardous waste recycling efforts, number of calls made to report illegal dumping into the storm sewer system or streams, and membership in citizen advisory groups.

Successful stormwater management efforts also depend on public support. Public support, in turn, depends upon its valuation of water resources. The public's valuation of a particular water body is usually based on more than water chemistry. Appearance, surroundings, ease of access, and apparent water quality are all considered by the average user. Being aware and understanding the public concerns and perceptions is an important, yet challenging, component in watershed restoration. Knowing who the staunchest advocates and critics are can go a long way towards being able to implement various programs and restoration measures.

The type and frequency of monitoring of public behavior and awareness can vary. Informal monitoring can occur by assessing attendance and interest at annual community functions and other environmental awareness initiatives. More formal resident surveys also have a role, and are recommended after about one year of the institution of a major public education campaign (e.g., pet waste and lawn care education). Questions in the survey should target whether the individuals are aware of the campaign, whether it has had impact on their behavior, and what recommendations they have to improve the message.

Monitoring social indicators directly ties into the public education and pollution prevention effort put forth by the City. A committed public education effort needs to incorporate follow-up surveys for the purposes of gaging the effectiveness of the program and to generate recommendations on how a program can be improved. The City already has an impressive community information and technology transfer infrastructure in place and can benefit from this network in terms of both the education goal and the response indicator assessment.

5.6 Implementation Schedule

Throughout the development of the Watts Branch Watershed Management Plan, the City of Rockville Department of Public Works has been evaluating and planning an implementation schedule for the priority projects. This planning has included budget considerations for the Capital Improvement Projects (CIP) list, need for other work in the Watts Branch stream valley such as sewer line rehabilitation, and concurrent scheduling for improvements approved in the Cabin John and Rock Creek watershed studies. Based on current budget planning and projections, the recommended projects which are City-owned or operated are slated for a staggered implementation over the next 10-year period. See Table 5.4 for the Watts Branch CIP Implementation Schedule. The City has started, and will continue to work with owners of private sites where watershed improvements have been recommended to facilitate those projects through the normal development process, environmental grant or public agency programs.

In light of the findings from this study, it is worth discussing the potential benefits of constructing 14 retrofit projects and nine stream rehabilitation sites on stream channel erosion and water quality. The total drainage area to be controlled by the 14 proposed retrofit sites will be approximately 1000 acres (see Table 3.5). Adding the drainage area being managed by the King Farm and those facilities proposed for the Fallsgrove, the total watershed area that can ultimately be managed by either an effective new stormwater practice or a retrofit is approximately 2020 acres or 3.2 square miles. Since the cumulative drainage area of Watts Branch within the City is approximately 6.5 square miles, it is realistic to assume that approximately 49% of the watershed will ultimately drain to an effective stormwater management facility. The nine stream rehabilitation sites have a total length of approximately 8,160 linear feet which is approximately 56 % of the total length of eroding stream identified through the RSAT inventory. Implementation of these retrofit and stream rehabilitation measures should result in significant reduction in pollutant load and help mitigate the continued channel enlargement process. The exact amount of pollutant load reduction and channel erosion mitigation will depend on the ultimate design configurations of the stormwater retrofits and stream rehabilitation sites, as well as the number of sites that are ultimately constructed.

Table 5.4 Watts Branch Capital Improvement Project (CIP) Implementation Schedule

WATTS BRANCH WATERSHED STUDY PROJECTS
PROPOSED CIP IMPLEMENTATION SCHEDULE FY2002-2012

WATTS BRANCH PROJECTS	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010	FY2011	FY2012
SM18 & SM20 (270 Industrial Park & Carnation Drive Ponds) & 204-5	***$81,000***		$259,000								
205-1 to 2, 204-1, 302-12; 205-5 to 8 (Upper Watts Br. Park Streamwork)					***$80,000***		$256,800				
SM23 (College Gardens Park Pond)			***$50,000***		$198,000						
O3 (Welsh Park Pond)				***$40,000***		$133,000					
302-3 to 4, 302-6, 302-8; 115A-1 to 3 (Woodley Gardens Park Streamwork)			***$70,000***		$193,000						
401-15 to 18, 103-1 to 2 (Woottons Mill Park-Upper Streamwork)	***$60,000***		$166,000								
401-8 to 11(Woottons Mill Park-Rockshire Streamwork)		***$40,000***		$110,000							
401-2 to 3, 401-5 to 6 (Woottons Mill Park-Lower Streamwork)									***$40,000***		$110,000
SM1, SM2 & SM3 (Horizon Hill Park Ponds)					***$88,000***		$293,000				
SM9 (Lakewood Country Club Pond)									***$10,000***		$35,000
SD8 & 103-5 to 8 (Glenora Park Pond & streamwork)							***$76,000***		$240,000		
301-2 to 4 (Woottons Mill Park-Rt. 28 trib streamwork)							***$30,000***		$83,000		
TOTAL YEARLY COSTS	**$141,000**	**$40,000**	**$545,000**	**$150,000**	**$559,000**	**$133,000**	**$655,800**	**$0**	**$373,000**	**$0**	**$145,000**

WATTS BRANCH GRAND TOTAL = $2,741,800

Bold italicized entries are design costs, regular entries are construction costs

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